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Graduate Catalog, 1996-1999, New Jersey Institute of Technology

New Jersey Institute of Technology

NJIT

1996
1999

New Jersey Institute of Technology

Graduate Catalog

Contents

This catalog contains the programs, courses, and requirements of graduate study at New Jersey Institute of Technology.

The provisions of this catalog do not constitute an offer for a contract which may be accepted by students through registration and enrollment in the university. The university reserves the right to change any provision, offering, or requirement at any time during the student's period of study at NJIT.

Fall 1996

Programs

Courses

NJIT was founded more than a century ago, created by industry, the city and the state to serve a growing industrial center. Students were attracted by the opportunity to work closely with faculty who had experience in business and government. They graduated into good jobs, and used their skills to help create a strong base of American manufacture and commerce.

Today, a renewed emphasis on science and technology in a world economy and the need for innovation in all sectors have led industry and government to form new partnerships with NJIT. These alliances have enabled the state's technological university to grow in breadth and depth.

NJIT's history begins in 1881 when its forerunner, Newark Technical School, was founded at the urging of the Newark Board of Trade to educate workers for the local manufacturing industries. In 1919, as the concept of the professional engineer gained acceptance, Newark Technical School began awarding baccalaureate degrees; eventually its name was changed to Newark College of Engineering. To this day, NCE is one of the most respected engineering colleges in the nation.

In 1973, the state of New Jersey selected the engineering college in Newark as the home for a new public school of architecture. Reflecting a now expanded mission, the institution was renamed New Jersey Institute of Technology. Today the School of Architecture at NJIT is the fifth largest architecture school in the nation and is widely recognized for its innovative integration of computer technology into the design curriculum.

Consolidation of NJIT's core courses in the applied sciences, mathematics and the humanities, along with rapid advances in computer science, resulted in the establishment in 1982 of the College of Science and Liberal Arts. Shortly thereafter, in 1988, the School of Industrial Management was formed to bring focus to the university's growing programs in management instruction and research.

The Albert Dorman Honors College was established in 1993 for those students who are prepared to undertake a particularly rigorous and individualized course of study.

The student body in all of our schools are diverse, dynamic and energetic—and among the most able in the state. More than 7,800 are enrolled, from freshmen to doctoral candidates. About one-third are enrolled in graduate studies.

Always known for the quality of its academics, NJIT has become a leader in interdisciplinary applied research. The university—which today is recognized as a full partner in the triad of New Jersey's public research universities—expends close to $32 million annually on research. Major funding is obtained from leading corporations, foundations and government agencies including the National Science Foundation, the U.S. Department of Defense, the U.S. Department of Transportation, the New Jersey Commission on Science and Technology, the U.S. Department of Transportation, the U.S. Environmental Protection Agency, the New Jersey Department of Environmental Protection and Energy, and many others.

Through the application of advanced technologies, NJIT researchers seek solutions to problems encountered by a range of organizations—from multinational corporations to local non-profit agencies. Efforts are focused especially on protecting the environment, finding new forms for the built environment and strengthening the nation's competitive position through advanced manufacturing, more productive transportation, and the skillful management of technology. NJIT is home to one of the nation's largest university-based environmental engineering and science centers, to a federally funded transportation research center, and to a leading manufacturing research and industrial outreach center.

NJIT features one of the most computerized campuses in the nation. Academic programs and administrative offices use technology in day-to-day activities. Students become proficient in the use of computers. A campus-wide fiber optic network links thousands of campus locations together and to computers around the world. And all full-time, first-time freshmen receive a personal computer and software packages to use while they are enrolled.

As we near the 21st century and face many new challenges, the original spirit of NJIT's forerunner, Newark Technical School, remains intact: to anticipate and respond to change, to educate a broad range of students to reach their full potential, to seek practical solutions for real problems, and to serve the dynamic community of which we are a part.

Mission Statement

NJIT is a public, urban research university committed to the pursuit of excellence in: undergraduate, graduate, and continuing professional education, preparing students for productive careers and amplifying their potential for lifelong personal and professional growth; the conduct of research in such multidisciplinary fields as environmental preservation, manufacturing, productivity enhancement, infrastructure systems, and communications technologies; contributing to the state's economic development through partnerships and joint ventures with the business community and through the development of intellectual property; service to both its local communities and the broader society of the state and nation by conducting public policy studies, making educational opportunities widely available, and initiating community-building projects.

NJIT prepares its graduates for positions of leadership as professionals and as citizens; provides educational opportunities for a broadly diverse student body; responds to needs of large and small businesses, state and local governmental agencies, and civic organizations; and advances the uses of technology as a means of improving the quality of life.

NJIT offers a comprehensive array of programs in engineering and engineering technology, computer science, architecture, applied sciences, mathematics, management, policy studies, and related disciplines throughout New Jersey and the nation.

Graduate Studies at NJIT

Graduate studies at NJIT are available to both the full-time student and the working professional interested in part-time study. Programs leading to the master's degree are offered by the graduate colleges and schools of NJIT, in 31 different disciplines, with many allowing more intensive specialization.

Programs leading to the Doctor of Philosophy degree are offered by the College of Science and Liberal Arts and by Newark College of Engineering, in 12 different disciplines, with several programs in science and mathematics offered in collaboration with Rutgers-Newark and the University of Medicine and Dentistry of New Jersey. Newark College of Engineering offers the Degree of Engineer in four engineering disciplines: chemical, civil, electrical and mechanical. Graduate certificate programs are offered in a number of disciplines on a timely basis to satisfy current professional needs.

Full-time students are likely to become involved with the extensive research activity at NJIT through association with renowned faculty and research centers. Financial support is available through a variety of programs that permit students to become part of the teaching, administrative, and research functions of the institute. Other non-service based support is also available.

Graduate courses and programs are also offered by NJIT faculty at off-campus sites through extension programs and by televised distance learning as part of NJIT membership in the National Technological University. Current undergraduates have opportunities for early entry into graduate study through the BS/MS program, University Scholars and accelerated joint degree programs.

Further information on financial support and details of academic programs are found in other sections of this catalog. Contact the Office of Graduate Studies at (201) 596-3462 for additional information.

Synopsis of Graduate Programs

Doctoral and master's degree programs are listed below. All doctoral programs lead to the Doctor of Philosophy degre; master's programs lead to the Master of Science degree in a specialization with the exception of the Master of Architecture, the Master in Infrastructure Planning, and the Master of Arts in History. The Degree of Engineer is offered in chemical, civil, electrical, and mechanical engineering. Graduate certificate programs are offered in a number of areas.

■ NEWARK COLLEGE OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING, CHEMISTRY AND ENVIRONMENTAL SCIENCE

Ph.D. in Chemical Engineering

M.S. in Chemical Engineering

Degree of Engineer in Chemical Engineering

Ph.D. in Chemistry (degree conferred by Rutgers-Newark)

M.S. in Applied Chemistry

Ph.D. in Environmental Science

M.S. in Environmental Science

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Ph.D. in Civil Engineering

M.S. in Civil Engineering
Areas of Specialization:
Construction Engineering
Construction/Facilities Engineering and Management
Environmental Engineering
Geoenvironmental Engineering
Geotechnical Engineering
Structural Engineering
Urban and Transportation Engineering

Degree of Engineer in Civil Engineering

Ph.D. in Environmental Engineering

M.S. in Environmental Engineering

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Ph.D. in Electrical Engineering

M.S. in Electrical Engineering
Areas of Specialization:
Biomedical Systems
Communication and Signal Processing
Computer Systems
Control Systems
Energy Conversion and Power
Microwave and Lightwave Engineering
Solid-State Materials, Devices and Circuits

Degree of Engineer in Electrical Engineering

M.S. in Computer Engineering

M.S. in Power Engineering (pending)

M.S. in Telecommunications (pending) (offered with the Department of Computer and Information Science)

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Ph.D. in Industrial Engineering

M.S. in Industrial Engineering
Areas of Specialization:
Quality and Reliability Engineering
Cost Engineering
Human Factors/Ergonomics
Operations Research and Decision Sciences
Production and Manufacturing Systems
Service Systems
System Analysis

M.S. in Manufacturing Systems Engineering
Areas of Specialization:
Automated Production Systems
Computer Control of Manufacturing Systems
Manufacturing Computer Systems Analysis and Design
Manufacturing Management Systems
Systems and Product Design

M.S. in Engineering Management
Areas of Specialization:
Cost-Engineering
Engineering Management
Project Management
Technical Marketing
Technological Entrepreneurship
Quality
Facility Management

M.S. in Occupational Safety and Health Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

Ph.D. in Mechanical Engineering

M.S. in Mechanical Engineering
Areas of Specialization:
Biomechanical Engineering
Particle Technology
Robotics and Controls
Design and Mechanisms
CAD/CAM
Energy Systems
Materials and Processing

Degree of Engineer in Mechanical Engineering

Interdisciplinary Programs

APPLIED SCIENCE COMMITTEE

M.S. in Applied Science
Areas of Specialization:
Biology
Chemistry
Mathematics
Physics

BIOMEDICAL ENGINEERING COMMITTEE

M.S. in Biomedical Engineering

ENGINEERING SCIENCE COMMITTEE

M.S. in Engineering Science

TRANSPORTATION COMMITTEE

Ph.D. in Transportation

M.S. in Transportation
Areas of Specialization:
Advanced Transportation Systems and Technologies
Transportation Administration
Transportation Engineering
Transportation Planning

■ COLLEGE OF SCIENCE AND LIBERAL ARTS

DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

Ph.D. in Computer Science

M.S. in Computer Science
Areas of Specialization:
Artificial Intelligence
Computer Algorithms and Theory of Computing
Computer and Information Systems Management
Computer Communications and Networking
Computer Systems and Parallel and Distributed Processing
Database and Knowledge-Based Engineering
Graphics and Image Processing
Numerical Computation
Software Engineering
Systems Analysis, Simulation and Modeling
Systems Integration

M.S. in Information Systems
Areas of Specialization:
Collaborative Systems
Databases
Data Communications
Expert Systems
Human-Computer Interaction
Graphical User Interface
Software Development
Information Systems Design
Knowledge-Based Systems
Simulation, Modeling and Decision-Support Systems
Industrial Management
Professional and Technical Communication
Industrial and Manufacturing Engineering

M.S. in Telecommunications (offered with the Department of Electrical and Computer Engineering)
Areas of Specialization:
Communication Systems
Networking
Information
Management and Administration

Ph.D. in Biomedical Informatics (pending) (offered with UMDNJ)

M.S. in Biomedical Informatics (offered with UMDNJ)
Areas of Specialization:
Health Sciences Teaching Systems
Health Information and Decision Support Systems

FEDERATED HISTORY DEPARTMENT OF NJIT AND RUTGERS-NEWARK

M.A. in History (offered with Rutgers-Newark)
Major Fields:
History of Technology, Environment and Medicine
American History
World History

M.A.T. in History (degree conferred by Rutgers-Newark)

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

M.S. in Environmental Policy Studies

M.S. in Interdisciplinary Studies

M.S. in Professional and Technical Communication

DEPARTMENT OF MATHEMATICS

Ph.D. in Mathematical Sciences (offered with Rutgers-Newark)

M.S. in Applied Mathematics
Areas of Specialization:
Analysis
Applied Mathematics
Computational Methods
Statistics

FEDERATED PHYSICS DEPARTMENT OF NJIT AND RUTGERS-NEWARK

Ph.D. in Applied Physics (offered with Rutgers-Newark)

M.S. in Applied Physics

Interdisciplinary Programs

MATERIALS SCIENCE AND ENGINEERING COMMITTEE

Ph.D. in Materials Science and Engineering (pending)

M.S. in Materials Science and Engineering (pending)
Areas of Specialization:
Electronic and Photonic Materials
Polymer and Biomaterials
Composite and Structural Materials

■ SCHOOL OF ARCHITECTURE

***Master of Architecture**

M.S. in Architectural Studies

Master in Infrastructure Planning

■ SCHOOL OF INDUSTRIAL MANAGEMENT

Ph.D. in Management (degree conferred by Rutgers-Newark)

***M.S. in Management**
Areas of Specialization:
Environmental Management
Financial Management
Human Resource Management
Information Systems Auditing
Management Accounting and Auditing
International Business
Marketing Management
Operations Management and Systems
Transportation Management

■ DIVISION OF CONTINUING PROFESSIONAL EDUCATION

†GRADUATE CERTIFICATES

Construction Management (relates to M.S. in Civil Engineering, M.S. in Engineering Management)

Continuous Process Improvement (relates to M.S. in Engineering Management)

Environmental Infrastructure and Management (relates to M.S. in Environmental Policy Studies; in part to M.S. in Management)

Environmental Site Remediation (relates to M.S. in Environmental Engineering; M.S. in Environmental Science)

Geographic Information System and Environmental Problems (relates to M.S. in Civil Engineering; M.S. in Engineering Science)

Health Care Information Systems (relates to M.S. in Management; M.S. in Biomedical Informatics)

Object-Oriented Design (relates to M.S. in Information Systems; M.S. in Computer Science)

Practice of Technical Communications (relates to M.S. in Professional and Technical Communication)

Programming Environment Tools (relates to M.S. in Information Systems; M.S. in Computer Science)

Project Management (relates to M.S. in Engineering Management)

Telecommunications Networking (relates to M.S. in Electrical Engineering; M.S. in Computer Science; M.S. in Telecommunications)

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*Dual Degree Offerings—
Master of Architecture/M.S. in Management
Master of Architecture/Master in Infrastructure Planning

†Graduate Certificates are offered in professional fields externally validated as "fast growing" with employment opportunities through the 21st century. Therefore, annual adjustments are made in the subject areas. Those listed here are available through June 1997.

Major Research and Public Service Centers

Engineering and Applied Science

Center for Applied Mathematics and Statistics (CAMS)
Fosters and supports the application of advanced mathematical and statistical methods to scientific, engineering, and management problems. (201) 596-8545.

Institute for Integrated Systems Research
Interdisciplinary research arm of the Department of Computer and Information Science. (201) 596-3387.

Multi-lifecycle Engineering Research Center
The center is dedicated to the development of innovative engineering methodologies and technologies incorporating re-use as a primary consideration in the design of new products; and to the education of new engineers and professionals with a broad knowledge of these systems. Targets cross-disciplinary thrust areas in multi-lifecycle product and process design, re-engineered materials from the waste stream, manufacturing and materials processing, demanufacturing systems technology, application, demonstration and integration. (201) 642-7198.

Particle Technology Research Center
Particle technology spans a host of industries and addresses the characterization, modification, flow, and utilization of granular solids or powders. The center conducts basic research and mathematical microlevel modeling; provides training to professionals as well as educates undergraduate and graduate students; develops cost-effective technology for existing and emerging industries, and facilitates its transfer to industrial partners. (201) 596-5829.

Environmental Engineering and Science

Hazardous Substance Management Research Center (HSMRC)[1,2]
Internationally recognized and the nation's largest industry/university cooperative research program dedicated to hazardous substance management. NJIT is the lead institution of the center's academic consortium whose other members include Princeton, Rutgers, Stevens and the University of Medicine and Dentistry of New Jersey. (201) 596-3233.

Northeast Hazardous Substance Research Center (NHSRC)[3]
University-sponsored research focuses on remediation technology for application at EPA Superfund sites. NJIT is the lead institution in an academic consortium whose other members include MIT, Princeton, Rutgers, Tufts, Stevens and the University of Medicine and Dentistry of New Jersey. (201) 596-5883.

Emission Reduction Research Center (ERRC)
Collaboration with industry on pollution prevention via a consortium whose members are NJIT, MIT, Ohio State, and Penn State. ERRC is the research arm of the university's integrated pollution prevention initiative. (201) 596-5850.

Center for Airborne Organics
NJIT has joined with Massachusetts Institute of Technology and California Institute of Technology in this national EPA center. The goal of the center is to provide tools to the EPA, industry, and the states—improved methodologies and predictive and interpretive models—to connect reliably the identities and concentrations of airborne organic compounds with major anthropogenic pollutant emission sources. (201) 596-5883.

Manufacturing

Center for Manufacturing Systems (CMS)[1]
CMS is devoted to research and technology extension and is actively engaged in research projects to develop new technologies in automation, machining, and factory floor integration. (201) 596-3615.
Units include: Advanced Manufacturing Laboratory (AML) which houses a full complement of advanced machine tools and a production scale, multi-layer extrusion line, (201) 596-8189; Center for Processing of Plastic Packaging (CPPP), which seeks ways to improve plastics processing and products for packaging applications through fancy automation and advanced engineering and manufacturing techniques, (201) 642-4582; hosted by NJIT, the New Jersey Manufacturing Extension Partnership (MEP) is the gateway to statewide services for small- and medium-sized manufacturers, offering connection to public and private sector providers who can address business, financial and technical issues essential to maintaining competitiveness, (201) 596-3615.

Transportation

Institute for Transportation
Interdisciplinary research on the transportation needs of the public and private sectors. Includes the National Center for Transportation and Industrial Productivity[4], which investigates methods for increasing productivity through transportation improvements. Provides technical, administrative and fiscal management necessary to conduct research projects in the field of transportation. (201) 596-3355.

Electronics and Communications

Center for Communication and Signal Processing
Promotes research on the theoretical and practical aspects of communications and signal processing in collaboration with government organizations and local industry. Emphasizes wireless and personal communication. (201) 596-3520.

Electronic Imaging Center
The center's research includes process and device simulation of new image sensor structures, design and layout of visible and infrared image sensors, and development of imaging/vision cameras and systems. Of particular interest are applications of infrared imaging and radiometry with industrial and commercial partners. (201) 596-5883.

Microelectronics Research Center
Research focuses on advanced semiconductor and micromachined device design and process technology. Features complete Class 10 cleanroom. Provides industry with technical support and prototype developments in CMOS and/or MEMS technologies (201) 596-5736.

New Jersey Center for Multimedia Research (NJCMR)[1]
NJCMR is a partnership of NJIT and Princeton University that fosters world-class research programs in multimedia research to enhance the competitive position of New Jersey and the region's multimedia technology industries. It also advances the state-of-the-art in education applications of multimedia technology (201) 596-5650.

Architecture

Center for Architecture and Building Science Research
This applied research group under the auspices of the School of Architecture, investigates the built environment within a social and economic context. Major areas of study include: housing, learning environments, healthcare and aging, disabilities, and the utilization of waste materials for construction and infrastructure. (201) 596-3097.

Small Business Assistance Centers

Center for Information Age Technology (CIAT)
Integrates computer technology into the operations of New Jersey business, government, non-profit and educational organizations. Provides technical assistance in computer technology for New Jersey small business, especially manufacturing firms. (201) 596-3035.

Defense Procurement Technical Assistance Center
Helps New Jersey small businesses obtain defense and other federal contracts. (201) 596-5807.

Enterprise Development Center[6]
Small business incubator that helps new and developing enterprises survive the typically difficult start-up stages. (201) 643-5740.

New Jersey Technical Assistance Program (TAP)[5]
Helps New Jersey small- and medium-sized businesses comply with state and federal pollution prevention regulations. (201) 596-5864.

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[1]Advanced Technology Center of the N.J. Commission on Science and Technology.
[2]National Science Foundation Industry/University Cooperative Research Center.
[3]Sponsored by the U.S. Environmental Protection Agency.
[4]Sponsored by the U.S. Department of Transportation.
[5]Sponsored by the N.J. Department of Environmental Protection and Energy.
[6]Sponsored by the N.J. Commission on Science and Technology.

Other Centers

Associated Institutions for Material Sciences (AIMS)[6]
Consortium with Princeton, Rutgers, David Sarnoff Research Center, Stevens, and the University of Medicine and Dentistry of New Jersey. Units include: the New Jersey center for Biomaterials and Medical Devices[6], which works to initiate major research programs and transfer technologies to New Jersey companies regarding implant design improvement and a better understanding of the relationship between living tissue and artificial implants, (908) 445-0488; and the Advanced Technology Center for Surface Engineered Materials, (201) 596-3561.

Center for Policy Studies
Concentrates on research in environmental policy, transportation policy and manufacturing policy, in collaboration with HSMRC, the Institute for Transportation, and CMS, respectively. (201) 596-8467.

NJIT Faculty Research

NJIT faculty conduct extensive research in the university's various research centers, in departmental laboratories, and in partnership with other universities, industry and government laboratories. Some of the major research activities are presented here. Additional information about the NJIT research centers mentioned below is available on page 6 and a listing of center directors is located on pages 144 and 145 of this catalog.

BIOMEDICAL ENGINEERING

NJIT's interdisciplinary biomedical engineering faculty are involved in research and development in collaboration with the following institutions:

- UMDNJ New Jersey Medical School
- UMDNJ New Jersey Dental School
- Saint Barnabas Medical Center
- Kessler Institute for Rehabilitation
- Veterans Administration Medical Center in East Orange
- Hackensack Medical Center
- John F. Kennedy Medical Center (Edison, N.J.)

Areas of Research

Mechanical Engineering—In the area of biomechanics research is ongoing in knee joints, heart valves, spinal disks, spinal fixation devices, and a quantification device for lower back pain. Biomaterials research focuses on artificial ligaments and resorbable fracture fixation materials.

Electrical Engineering—Researchers in biomechanical signal processing are developing electrocardiogram analysis as a tool for diagnosing and treating stroke disorders and neuromuscular disorders. Other signal processing research involves electroencephalogram analysis in treating epilepsy and electromyogram analysis in fatigue studies.

Chemical Engineering—Modeling and simulation of the cardiovascular system is being developed to automate and optimize anesthetic gases to a surgery patient. Researchers are using molecular modeling of salt receptors to help create salt substitutes for foods and other applications. Molecular modeling also is being used to study acetylcholinesterase in nerve impulse transmission.

CHEMICAL ENGINEERING, CHEMISTRY AND ENVIRONMENTAL SCIENCE

The chemical engineering, chemistry and environmental science research programs are closely associated with the:

- Hazardous Substance Management Research Center
- Northeast Hazardous Substance Research Center
- Emission Reduction Research Center
- Center for Processing of Plastic Packaging
- Microelectronics Research Center
- Particle Technology Center
- Multi-lifecycle Engineering Research Center

Additional Areas of Research

Membrane Separations—Excellent facilities exist for conducting research on membrane separation processes, particularly hollow-fiber membranes. Applications include gas-gas, gas-liquid, and solute-liquid separations, as well as combined reaction/separation processes. Support for these activities comes from industrial and federal research grants, the environmental research centers at NJIT, and NJIT's Sponsored Chair in Membrane Separations and Biotechnology.

Hazardous Waste Treatment and Waste Minimization—Dynamic modeling of biological reactors, anaerobic/aerobic biotreatment processes, in-situ bioremediation, biofiltration of VOCs, kinetic and thermodynamic analysis of combustion and pyrolysis processes, acid gas treatment, transport and kinetic modeling of photochemical reactors, sampling and analysis of organic and inorganic pollutants, supercritical extraction, treatment of gaseous pollutants by corona discharge, novel routes for solvent-less chemical synthesis, ultrasonic enhancement of in-situ remediation, and process design for waste minimization.

Biochemical Processing—Reactor analysis, mixing phenomena, chromatographic separations, blood chemistry, and molecular modeling of enzyme and taste mimetics.

Solid State and Polymeric Materials—Engineering analysis and experimental investigation of chemical vapor deposition (CVD) processes, particle flow systems, polymer characterization and process engineering.

CIVIL AND ENVIRONMENTAL ENGINEERING

Research in civil and environmental engineering is conducted within the department and in these NJIT centers:

- Center for Manufacturing Systems
- Emissions Reduction Research Center
- Multi-lifecycle Engineering Research Center
- Hazardous Substance Management Research Center
- Institute for Transportation
- Northeast Hazardous Substance Research Center

Additional Areas of Research

Geoenvironmental Engineering Laboratory—This state-of-the-art facility was established using a $1 million grant from the National Science Foundation which was matched with more than $2 million from NJIT. It provides research support for geoenvironmental projects such as soil decontamination using biological, chemical and/or physical means; modeling of contaminant transformation and transport; and the testing of waste treatment, solidification, and stabilization and containment systems. Some of the most significant pieces of equipment include an environmental scanning electron microscope (ESEM), X-ray fluorescence and X-ray diffraction spectrometers (XRF/XRD), GC/MS and SFE, capillary electrophoresis (CE), UV-VIS, FT/IR, respirometers, particle size analyzer (PSA), and hydraulic conductivity apparatus.

High Performance Concrete Laboratory—Equipped with funds from the National Science Foundation, this laboratory is the only academic facility capable of testing very high strength concretes under uniaxial as well as triaxial states of stress. The primary testing system at this

facility is capable of applying up to one million pounds of axial load on a specimen in a computer controlled closed-loop environment. The materials processing component of the facility includes two computer controlled micro-sizers, and fractionators for particle size analysis and categorization of industrial by-product additives to concrete, i.e. fly-ash, microsilica, and blast furnace slags.

Smart Sensors and Nondestructive Testing Laboratory—This laboratory provides means for studying self-sensing systems built into structures to monitor excessive strains, deflections, load distributions, temperature variations and corrosion. It is unique in the sense that the researchers involved comprise an interdisciplinary group of scientists and engineers from civil, electrical, and chemical engineering, as well as physics. The laboratory is primarily involved in developing fiber optic sensor systems that will be embedded in concrete and other composites. The facility is equipped with a number of laser systems, optical spectrum analyzers, speckle based video systems, bench top materials testing systems for calibration of sensors, and supporting electronic instrumentation.

Recycled Plastics Laboratory—This research facility concentrates on developing economical traffic noise barriers and safer road barriers that use new materials and designs. In addition to material tests, the lab develops constitutive models and analysis techniques required by the nonlinear characteristics of the material and its variation through the cross section. Computer simulations are used to analyze the barriers during a crash by modifying current programs to include recycled plastic models. Experimental studies include wind and acoustic tests of noise barriers and in-situ implementation of the proposed designs.

COMPUTER AND INFORMATION SCIENCE

Computer and information science research at NJIT is conducted mainly in the Institute for Integrated Systems Research (IISR), which consists of these laboratories: Advanced Computer Architecture and Parallel Processing; Artificial Intelligence; Collaborative Systems; Computer Communications and Networking; Computer Vision; Data and Knowledge Engineering; Electronic Enterprise Engineering; Hypermedia Information Systems; Integrated Systems; Multimedia Systems; Real-Time Computing; and Software Engineering.

Areas of Research

IISR provides the department research laboratories with infrastructure, coordination and promotion for conducting multidisciplinary research and development. It sustains an interdisciplinary research support environment for enterprise engineering, microelectronics, computer engineering, manufacturing systems, health care information systems, and other disciplines. IISR concentrates on improving productivity in the service and manufacturing industries, acting as a conduit for the transition of innovative research prototypes to technological marketplaces. It also shares knowledge and experience of integrating enterprise information, process structures, coordination and infrastructure needed in finding solutions to problems.

ELECTRICAL AND COMPUTER ENGINEERING

Most of the research conducted in the Department of Electrical and Computer Engineering is affiliated with the:

- Microelectronics Research Center
- Electronic Imaging Center
- Center for Communication and Signal Processing
- Multi-lifecycle Engineering Research Center

Additional Areas of Research

Drexler Thin Film Laboratory—Researchers in this laboratory study processing and properties of materials and structures in the form of thin films. This facility has a number of thin film deposition systems, including a state- of-the-art Ultrahigh Vacuum Chamber that permits deposition on atomically clean surfaces. Thin film structures, basic elements of modern microelectronic and optoelectronic devices, are increasingly important in almost all areas of technology. Current research includes metal epitaxy on silicon, modification of surfaces with atomic and cluster ions, and development of novel dielectrics with properties controlled by light beams.

Microwave and Lightwave Engineering—Research is ongoing in the areas of microwave device modeling and measurement, CAD of microwave components and systems, characterization of RF/microwave/optical systems, monolithic microwave integrated circuit design and testing, numerical electomagnetic codes, analysis design and wire antenna multiscattering in vegetation, experimental and theoretical study of linear and semiconductor surfaces, integrated optics, fabrication and characterization.

HUMANITIES AND SOCIAL SCIENCES

The department integrates the humanities and social sciences for the purpose of understanding the cultural, social, and scientific contexts informing contemporary culture. Special emphasis is given to research in these areas: the study of science, technology, and society; the study of communication; the study of environmental policy; professional ethics; the study of economics; and the study of multicultural and international literature. The department is committed to using the humanities and the social sciences as a coherent model for examining human society. Research is conducted in these centers:

- Center for Policy Studies
- Air Emission Reduction Research Center
- Center for Architecture and Building Science Research

Areas of Research

Environmental Studies—Research is ongoing in policy studies, coastal geomorphology, economics, ethics, history, communications, and education. The nationally acclaimed environmental journal *Terra Nova* is hosted by the department.

Professional and Technical Writing—Multimedia design, distance learning, writing assessment, and environmental communications are areas that faculty currently pursue.

Contemporary Literature—This research area includes modern poetry, multicultural and international studies, and the relationship between literature and the natural world.

INDUSTRIAL AND MANUFACTURING ENGINEERING

The Department of Industrial and Manufacturing Engineering has a significant and diverse research program that includes areas such as industrial and operations research, design for manufacturing, quality, assembly and concurrent engineering, robotics, global networking, logistics and simulation issues of small- and medium-sized companies, multimedia, environmental and health/safety and medical engineering. Research also is affiliated with these major NJIT research centers:

- Center for Manufacturing Systems
- Multi-lifecycle Engineering Research Center

Additional Areas of Research

Industrial Engineering, Systems and Operations Research—This main research area includes the development of control and scheduling algorithms for the optimization of container terminal operations, global networking and logistics operations for small, medium and large corporations, the impact of telecommuting strategies on traffic flow, engineering system modeling and design tools, distributed virtual laboratory networks between research groups, the R&D of quality systems, quality control and management systems.

Manufacturing Systems and Mechatronics Engineering—The department is active in robotics, robot cell design, flexible computer integrated manufacturing, system integration of automation systems, flexible assembly system modeling, integration, implementation, non-contact sensing and inspection, CAD/CAM integration, servo pneumatic positioning, and sensor technology.

Concurrent/Simultaneous and Total Lifecycle Engineering—A new research field, it involves areas such as the development of new methods and toolsets for small batch luxury automobile manufacturers (such as Rolls-Royce Motor Cars), and general methods, tools and technologies for design for manufacturing, design for quality manufacturing, assembly and maintenance systems.

Medical, Environmental, Health and Safety Engineering—Activity in this area is increasing. Main areas include the assessment of the realistic impact of environmental factors on productivity, devices and methods for the prevention of repetitive motion injuries, micro-robotic manipulators for human artery cleaning, and new medical devices coupled with simulators and expert systems that can be used for interacting with the human body and other medical applications.

Multimedia, Simulation and Virtual Reality Modeling—Research activities are spread between discrete event and continuous system modeling and simulation and areas such as graphical modeling of workcells, object-oriented simulation coupled with AI, engineering multimedia developments for the study of servopneumatic positioning, multimedia for total quality management and the ISO9001 standard, flexible automation, concurrent engineering and the virtual reality simulation (and rapid prototyping) of complex electromechanical products and their manufacturing/assembly processes.

MATHEMATICS

The research interests of the faculty focus on the development and use of mathematical tools for solving scientific, technological and industrial problems. The Center for Applied Mathematics and Statistics promotes and represents the research interests of all NJIT mathematics faculty. Specific areas of concentration and problems of current interest include:

Fluid Mechanics—Stability theory, interfacial and particulate flows, reacting flow and combustion phenomena, and computational methods.

Electromagnetics—Microwave processing of materials, scattering from complex structures, optical fibers, and wave propagation in media.

Acoustics—Wave propagation in the ocean and determination of ocean structure, source localization, and array signal processing.

Biology—Models of locomotion, diffusive-reactive systems, and neuron modeling.

Statistics—Estimation and reliability theory, time series analysis, and signal processing.

MECHANICAL ENGINEERING

The scope of research conducted in the Department of Mechanical Engineering is broad. Projects are carried out within the department's laboratories as well as in collaboration with the:

- Center for Manufacturing Systems
- Center for Processing of Plastic Packaging
- Hazardous Substance Management Research Center
- Multi-lifecycle Engineering Research Center
- Particle Technology Center

Additional Areas of Research

Bearings and Bearing Lubrications—Projects include the investigation of the effects of multigrade oils, synthetic oils and bearing materials in machinery. Also, the stick-slip friction phenomena are being investigated. Currently, research activity is focused on enhancing motion precision through modeling and compensation of friction in high-precision, electromechanical systems.

Intelligent Manufacturing—This laboratory advances CAD/CAM technologies such as process planning, robots, sensors, actuators, and other elements of industrial automation. Current research projects include optimal robot trajectory planning and control, geometric modeling and analysis of solid sweeping, analysis and control of parts mating in compliant assembly and CAD/CAM integration for automatic PCB assembly.

Machine Vision and Motion Analysis—Experimental work in this laboratory is concerned with the analysis of spatial linkages such as the Cardan, tripod and Rzeppa shaft couplings. Current projects also include pattern recognition, development of adaptive fuzzy clustering algorithms with applications in image processing, 3-D motion tracking for study of particle collisions, development of algorithms for automated motion analysis and machine vision applications for manufacturing.

Turbulence—This computational, theoretical fluid dynamics laboratory is dedicated to the prediction of transitional and fully developed turbulent flows. Advanced space-time data analysis of the numerically simulated flows is performed and used toward efficient turbulence modeling and control. Current research includes boundary layer and channel flows, film flows, ocean water waves, propagating flames, and wake flows.

Waterjet Machining—This facility develops technologies for the manufacture of complex precision and ultraprecision components from hard-to-machine materials—specifically structural and electronic materials. Current projects include development of an expert system for off-line control of waterjet machining, technology for 3-D glass milling, mathematical modeling of high-speed water flow, computer modeling of material destruction with water jets and development of ice-jet machining technology.

PHYSICS

Faculty are involved in various interdisciplinary research projects conducted primarily in these NJIT centers:

- Microelectronics Research Center
- Electronic Imaging Center

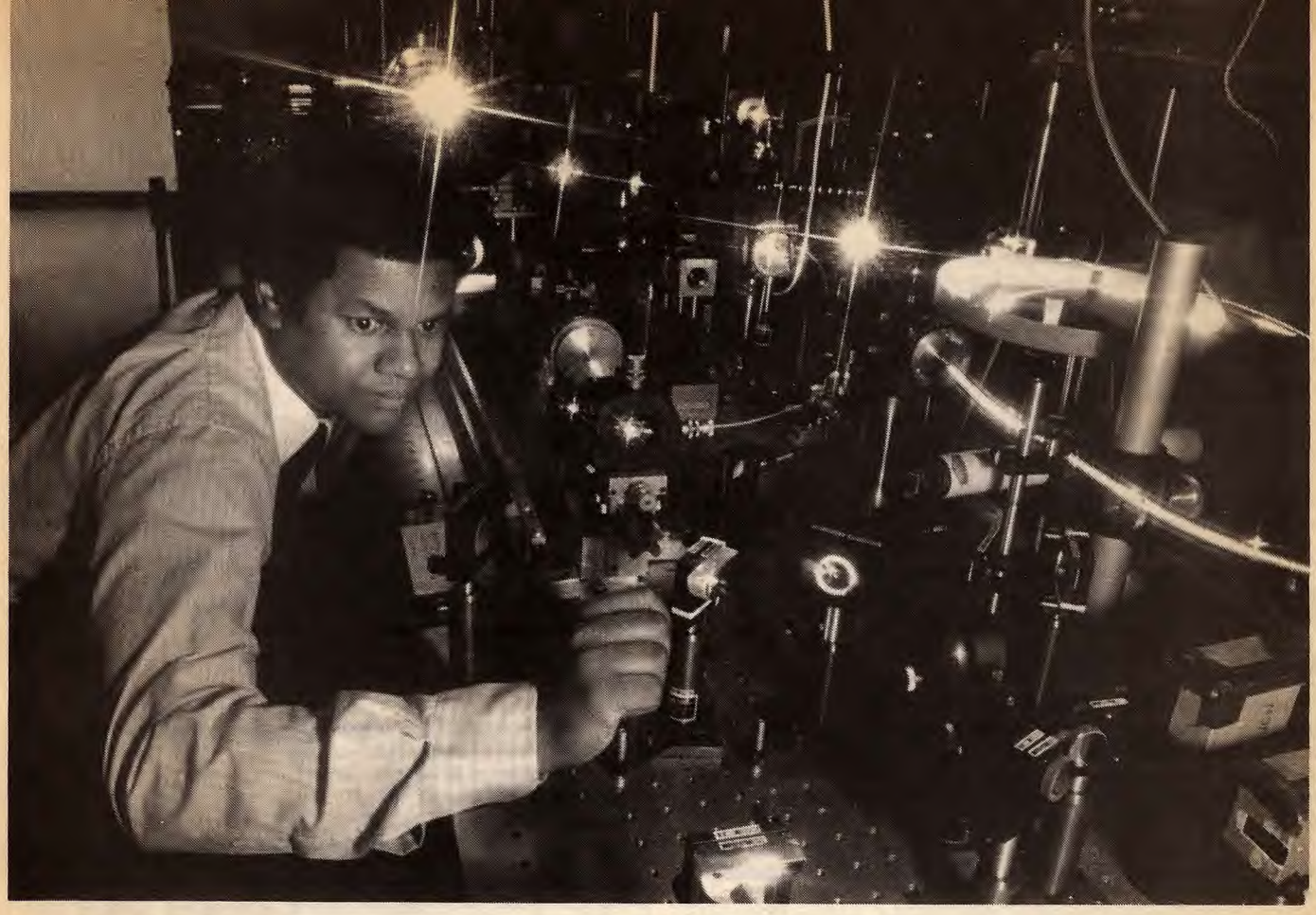
Additional Areas of Research

Device Physics—Research at NJIT is underway in silicon microfabrication, micromachining and fusion bonding for conventional and novel microelectromechanical (MEMS) device applications, metal-insulator-semiconductor device structures and rapid thermal processes in silicon integrated circuits. Studies at Rutgers-Newark involve sensors for biophysics applications. Facilities for this work include state-of-the-art metrology electrical characterization equipment, cryostats for very low temperature measurements and access to NJIT's Class 10 clean room with full process capabilities for 6-inch silicon wafers.

Materials Research—Molecular beam epitaxy (MBE) of II-V semiconductors is used to fabricate various photonic devices, digital integrated circuits, and optoelectronic integrated circuits. Research on the synthesis and characterization of chemical vapor deposited (CVD) and physical vapor deposited (PVD) silicon-based dielectric films is ongoing. Optical characterization of materials includes visible and far-infrared spectroscopy, photoconductivity, photoluminescence, spectral emissiometry and thermal modulation spectroscopy. Materials studies include photoinduced superconductivity in High-T_c materials (i.e., YBCO) and optical properties of SiC, GaN and porous silicon.

Ultrafast Optical and Optoelectronic Phenomena—Terahertz spectroscopy is used to study ultrafast carrier dynamics in semiconductors. Other areas include ultrafast photodetectors, ultrashort nonlinear pulse propagation in optical fibers and planar waveguides, and the ultrafast photophysics of semiconductor and quantum well devices.

Infrared Solar Physics—A developing initiative builds upon NJIT's nationally recognized work in infrared imaging technology, applying it to the promising area of infrared solar physics. State-of-the-art infrared imaging devices are being developed and tested as part of an IR telescope system to be installed at a solar observatory.



SCHOOL OF ARCHITECTURE

Architecture faculty conduct individual as well as interdisciplinary research mainly through these centers:

- Center for Architecture and Building Materials Research
- Multi-lifecycle Engineering Research Center

Additional Areas of Research

Building Technologies and Sciences—Moisture in buildings, building materials, energy transfer through building envelopes, conservation and passive solar heating, building systems integration, and building economics.

Computer-Aided Architecture—Use of computers in architectural practice, modeling and simulation, computer application in architectural design, and data structures and graphic representation.

History and Theory of Architecture—Architectural theory and criticism, history of architecture since 1750, urban history and cultural geography, literary themes in architecture, and contemporary art and architectural criticism.

Housing Studies and Urban Design—Housing for new household types, public policies in design arts, technology and architectural design, social meaning of building form, housing environments, community revitalization, and economic development.

Urban Infrastructure Planning—Interdisciplinary project planning and design, infrastructure technology and design principles, public space infrastructure, history and theory of urban infrastructure, and financing and implementation of infrastructure projects.

SCHOOL OF INDUSTRIAL MANAGEMENT

Management faculty are actively pursuing research conducted in affiliation with the:

- Center for Manufacturing Systems
- Multi-lifecycle Engineering Research Center
- Center for Policy Studies

Additional Areas of Research

Entrepreneurship and Small Business—Assessment of emerging technologies, economics, employment growth, theories and practice in relation to entrepreneurship and private enterprise.

Building Production and Management—Building efficiencies, organization of international construction, environmental technology management, and industrial ecnology systems.

Behavioral Science and Organizational Theory—Organizational design and development, organizational behavior, occupational and organizational socialization, legal and ethical issues, public administration, social perception, leadership, attachment and commitment processes in organizations, and transportation behavior.

Economics and Finance—Mathematical programming and multi-criteria decision making in financial management, portfolio analysis, emerging international capital markets, applied corporate finance, financial economics, public finance, international competitiveness of U.S. economy, and international economic/financial relationships.

Human Resources Management—Managing new technology, labor management relations, public policy and technological change, and tasks and unit level technologies.

Information Systems Management—Policy analysis, computer auditing, control and security, interface design, systems evaluation, technological forecasting and assessment, management information systems, management and social impacts of computer and information systems, group decision support systems, and database analysis.

Information Systems Auditing—Operational auditing, internal auditing.

Marketing Management—Marketing research, new product management, consumer behavior, international marketing, marketing technological innovation, mathematical programming and multi-criteria decision making, strategic management, sales management, enhancing global competitiveness, and technology transfer.

Operations Management—Project management, industrial quality control, production planning, management of manufacturing systems, and mathematical programming and multi-criteria decision making.

Corporate Law and Ethics—Employment law, legal and ethical issues in business, international legal environment of business, job security, and unlawful discharge/unjust dismissal.

NJIT Campus

Located in the University Heights section of Newark, New Jersey Institute of Technology's 45-acre campus is adjacent to the campuses of Rutgers, The State University of New Jersey; Essex County College; and the University of Medicine and Dentistry of New Jersey. The campus is easily reached via interstate highways and public transportation. Newark International Airport and the Pennsylvania Railroad terminal are close by.

In the first phase of a major expansion program, NJIT recently constructed buildings to augment student housing, physical education facilities, classrooms, laboratories, and offices. The library, School of Industrial Management, admissions offices and electrical and computer engineering facilities are now in a new building. The second phase of this expansion includes renovations of existing university facilities to provide additional space for the School of Architecture and civil engineering and to consolidate offices related to Student Service functions in a one-stop Student Mall housing Financial Aid, Bursar's and Registrar's offices and the Bookstore. Construction of a fourth residence hall is part of this phase.

NJIT's campus is home to major centers sponsored by the New Jersey Commission on Science and Technology. NJIT's three-story Otto H. York Center for Environmental Engineering and Science houses the Commission-sponsored Hazardous Substance Management Research Center, an internationally recognized leader in environmental research.

The 187,000-square-foot William S. Guttenberg Information Technologies Center houses the Commission-sponsored Center for Manufacturing Systems. The building is the site of the computer and information science, manufacturing engineering, and industrial engineering instruction and research facilities. A two-story "factory of the future" is an important feature of the building.

The campus center has a cafeteria and a more informal eating facility, The Pub. In addition, there is a theater on campus where student productions are staged, an athletic field, tennis courts and indoor recreational facilities including a swimming pool, racquetball courts, weight rooms, track, aerobics room, and more. The residence halls provide dormitory and apartment-style co-ed living accommodations for close to 1,200 students.

Accreditation

NJIT is accredited by the Middle States Association of Colleges and Schools (MSACS). The architecture program is accredited by the National Architectural Accrediting Board (NAAB). The B.S. program in computer science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB). The engineering programs of chemical engineering, civil engineering, electrical engineering, industrial engineering, and mechanical engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET). The programs in manufacturing engineering and computer engineering are new and are not yet eligible for EAC of ABET accreditation. In the Engineering Technology program, the options in construction and contracting, electrical, manufacturing and mechanical are accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET). The surveying engineering technology option is new and is currently being reviewed by TAC of ABET. ABET publications of accredited colleges and universities will be made available to students who are interested in verifying that the programs of Newark College of Engineering are accredited by EAC or TAC of ABET.

The Foundation at NJIT

The Foundation is a privately incorporated resource development organization that supports excellence in instruction, research, and public service programs at New Jersey Institute of Technology. The Foundation encourages private philanthropy on behalf of the university. It offers grants to faculty to encourage advanced research and funds faculty chairs of excellence. Currently, chairs in applied mathematics and optoelectronics are supported by the Foundation. NJIT's Board of Overseers has leadership and fiduciary responsibility for the Foundation.

Computing

NJIT features one of the most computerized campuses in the nation. The campus-wide network connects more than 500 computing nodes consisting of a combination of mainframes, massively parallel computers, high-end graphics processors, UNIX workstations, client-server nodes and personnel computers. These extensive and powerful computing facilities support academic study, research and all administrative functions and are accessible from nearly 2,000 locations across the campus.

Primary academic computing is provided by two time sharing computers, one using the UNIX operating system and the second utilizing the VMS operating system. For both computing and design applications there are more than 400 UNIX workstations and a similar number of PCs in locations across the campus. There is unrestricted access to all computers on campus with the exception of a few located in sponsored research laboratories.

The university is home to the Electronic Information Exchange System (EIES) international network. EIES, a pioneer in the field of computerized conferencing, has specially designed education features including question-response and exam activities, an electronic gradebook and binary file attachments. The EIES 'Virtual Classroom' is used in conjunction with televised and videotaped lectures to provide feedback among students and instructors. The Virtual Classroom is also used in the M.S. in Management executive program.

NJIT has Internet, ADPNet and a modem pool for off campus connectivity. NJIT's Internet connection services are provided by the John von Neuman Computer Network at T1 speed (1.5 Megabits per second). The Internet enables the NJIT community to reach any Internet service in the world 24 hours a day.

ADP Corporation, through its ADPNet service, provides nationwide direct dial capability from over 200 locations into its network and then to a direct connection to NJIT. The ADP network enables members of the NJIT community to access the university's computer network for as little as $1.50 per hour when away from the campus.

For local off campus access, NJIT maintains a pool of 128 modems operating at 28,800 baud. These modems enable off campus users to gain access to all university computer systems and full Internet access including WWW and Mosaic/Netscape.

All students and faculty are encouraged to make full use of the computing facilities including E-mail. No fees are charged, other than a small charge for supplies each semester. Students may obtain accounts by simply following an on-line tutorial in one of the many computer labs. Once a student has an account, he/she may take advantage of an on line, self registration system to enroll in courses for subsequent semesters. Also, students may opt for direct connectivity from their dorm room PC to the Internet for a nominal fee. The service is provided by semester and charges are assessed accordingly.

Library Services

The university's Robert W. Van Houten Library is located in a 1992 building and supports study, research and browsing. The library has a collection of 157,000 volumes. The library currently subscribes to 1,129 technical journals. In addition to NJNEER, the NJIT library catalog, a wide array of information services is available.

The library offers innovative Internet access to UnCover, a database containing citations and occasional abstracts to articles in 16,000 journal titles covering many disciplines. Coverage begins about 1989 and runs to the present. Articles can be sent directly to a designated fax machine.

Journal literature in engineering, science, management, architecture and other subject areas is accessible through a variety of indexing and abstracting publications including the Engineering Index Compendex*Plus database on the campus computer network. In addition, there are CD-ROM subscriptions to INSPEC (Science, Computer and Control, Electrical and Electronics, and Physics Abstracts), Applied Science and Technology Index, American Business Index, and ABI/INFORM (business). In addition, the library subscribes to a large number of printed abstracts and indexes.

The librarians provide individualized reference services, literature

searches, and instruction in the use of information resources. There are nine professional librarians providing such services, each holding a master's degree in library science and, among the group, degrees in chemistry, electrical engineering, industrial engineering, information science, art, mathematics, and liberal arts. They also act as liaisons to NJIT academic departments in materials selection and assistance.

The Architecture Library, a branch of the university's Van Houten Library, is located in the School of Architecture. A core collection of architecture information materials covers theory to practice, and history to implementation. The materials include books, journals, architecture videos, maps, product literature, models, and more than 70,000 slides. Access to architecture journal articles is provided by the Avery and Art indexes on CD-ROM.

Students may supplement NJIT library resources by borrowing from Rutgers-Newark's Dana Library, the University of Medicine and Dentistry of New Jersey's Smith Library, Newark Public Library, and the libraries of the eight state colleges: Jersey City State College, Kean College of New Jersey, Montclair State University, Ramapo College of New Jersey, Rowan College of New Jersey, Stockton State College, Trenton State College, and William Paterson College of New Jersey.

A small museum, containing items developed and manufactured by Edward Weston, scientist, prolific inventor, and a founding member of the board of trustees for the university, also is included among the library's resources. In addition, his rare book collection is available to scholars and others interested in the history of science and technology.

The library's World Wide Web home page on the Internet can be reached at URL: http://www.njit.edu/njIT/Library/Welcome.html. The library also can be reached by calling (201) 596-3210 (reference desk) or (201) 596-6371 (circulation desk).

Continuing Professional Education

NJIT continuing professional education offers five major programs. These include extension programs, ACCESS/NJIT distance learning, graduate certificates, and non-credit professional development and corporate customized training. Each provides adults with a distinctly different career-long learning opportunity.

Professional development programs include short courses, certificates and license reviews, with some leading to the award of continuing education units (CEUs). The CEU is used nationally to document the type, quality and duration of study. In general, one CEU is defined as being equal to 10 classroom hours. Beginning throughout the year, individual classes typically last one to five days, whereas certificates and license review can entail a significant number of hours of instruction spanning several months.

In addition, every professional development course, as well as many others, can be adapted to meet a particular organization's need and conducted as a custom-designed training program at a company site. For more than 50 years, NJIT has been designing and conducting non-credit courses that meet technology-based organizations' needs for high quality, lifelong workforce education. More than 375 courses are available in 17 subject areas.

Twelve-credit Graduate Certificates, which are also applicable to NJIT master's degrees, are available to those seeking career upgrading and change. A certificate can be acquired in one calendar year by attending classes either on campus evenings and Saturdays, or through new video/electronic means that are neither time- nor distance-bound. For further information see "Graduate Certificates" in this catalog or contact the Division of Continuing Professional Education.

Extension Programs

Although the majority of academic programs are offered at NJIT's Newark campus, students may take courses and earn degrees in other areas of the state through the university's extension programs. Admissions requirements and the quality of instruction are the same for on-campus and extension programs. Registration, advisement, and support services are available at each site listed below.

Atlantic County at the FAA Technical Center: courses leading to completion of Master of Science degrees in Computer Science, and Information Systems.

Bergen County at Bergen County Community College: courses leading to completion of a Master of Science degree in Engineering Management.

Bergen County at Ramapo College: courses leading to completion of Master of Science Degrees in Computer Science, Information Systems, and Management.

Burlington County at the NJIT Technology and Engineering Center: Master of Science Degrees are available in Computer Science, Engineering Management, and Information Systems.

Mercer County at the Department of Transportation: courses leading to the completion of a Master of Science in Transportation.

Mercer County at the Department of Environmental Protection: courses leading to the completion of a Master of Science in Environmental Science.

Mercer County at Hightstown High School: courses leading to the completion of a Master of Science in Engineering Management.

Morris County at Drew University: courses leading to Master of Science Degrees in Computer Science, Information Systems, and Management.

For more information about these and other off-campus programs, call the Office of Extension Programs at (201) 596-3640.

ACCESS/NJIT Distance Learning

The Office of Distance Learning has the responsibility for development and administration of college courses delivered through telecommunications technology.

The office operates ACCESS/NJIT, through which students remote from the campus—distance learners—earn college credit for enrollment in *telecourses*. Each telecourse combines video media with electronic interaction through telephone, fax, and/or computerized conferencing under the management of an NJIT course mentor. Telecourses allow for a flexible, yet rigorous, educational experience suited to motivated students. Students successfully completing these telecourses receive college credit.

The program's reach is nationwide and international. Transmission of course material is accomplished through cable cast, wireless cable, compressed digital teleconferencing, and VHS tape distribution. In addition, ACCESS/NJIT originates programming for the National Technology University (NTU), a satellite-distributed provider of graduate courses for technological professionals.

The Office of Distance Learning also oversees the production of educational material for distance learning. The current inventory covers two full graduate degrees (M.S. in Engineering Management and M.S. in Information Systems) and two full undergraduate degrees (B.A. in Information Systems and the B.S. in Computer Science), graduate certificates, and courses in many disciplines including science, computer science, mathematics, engineering, and management via distance learning. ACCESS/NJIT offerings are listed in the Continuing Professional Education (CPE) Catalog, available upon request.

ACCESS/NJIT furnishes a convenient alternative to distance learners and students who have scheduling conflicts. In addition, ACCESS/NJIT telecourse material can be used by any NJIT student needing course review. Several campus workstations in the Interactive Learning Center are set up for viewing.

For more information, contact the Office of Distance Learning at (201) 642-7015.

NJIT-Burlington County College Technology and Engineering Center

Students may earn a master's degree in South Jersey at the new state-of-the-art Technology and Engineering Center (TEC) in Mt. Laurel. The new education facility is a joint enterprise of NJIT and Burlington County College. TEC offers an M.S. in Computer Science, an M.S. in Information Systems, and an M.S. in Engineering Management. In addition to graduate degree programs, the TEC offers specialized classes via distance learning, graduate certificate programs and continuing professional development courses. For additional information about this branch campus, call 1 (800) 222-NJIT.

Consortium with Rutgers University-Newark and UMDNJ

Adjacent to NJIT is the Newark campus of Rutgers University, which has a student enrollment of approximately 10,000. NJIT and Rutgers-Newark enjoy an exceptionally close and productive consortial relationship within the thriving "University Heights" section of Newark. Each year thousands of students from the two institutions take courses at the others. In addition, the two universities co-sponsor a common season of theatrical productions, as well as "World Week," a joint program of honors colloquia, and a variety of other cultural and social activities. NJIT students have library privileges at the Dana Library of Rutgers-Newark. This arrangement enriches educational opportunities by enabling students to enroll in Rutgers-Newark courses in arts and science disciplines not offered at NJIT, such as art, music, foreign languages, biology, and geology; and many Rutgers-Newark courses are regularly listed in the NJIT registration bulletins in order to facilitate the cross-registration process. Joint or cooperative degree programs now exist in several graduate and undergraduate fields. As a result of this consortial relationship, the opportunities available to students at both universities are greatly enhanced.

Although there are currently fewer students involved, NJIT also enjoys a similar relationship with the University of Medicine and Dentistry of New Jersey (UMDNJ). UMDNJ is New Jersey's university of the health sciences. Its 45-acre Newark campus houses one of its three medical schools, a dental school, a graduate school of biomedical sciences, a school of nursing and a school of health related professions, as well as University Hospital and a community mental health center. UMDNJ is also a partner in the University Heights Science Park, the 52-acre high tech industrial complex in development adjacent to the NJIT campus. Affiliated with more than 100 health care and educational institutions statewide, UMDNJ is a partner in numerous research enterprises, including the Center for Advanced Biotechnology and Medicine, the Environmental and Occupational Health Science Institute, and the Cancer Institute of New Jersey.

Division of Career Development Services

The Division of Career Development Services (CDS) comprises the offices of Career Planning and Placement, Cooperative Education and Internships, Student Employment, and Community and Public Service, and NJIT's Alumni Career Services. All services are available either on a drop-in basis or by appointment.

These services are also available on-line via the Internet. Connect to the CDS homepage at http://www.njit.edu/njIT/Directory/Admin/Career/Welcome.html. The welcome page provides several job-related links that allow on-line users to browse job openings in several majors and concentrations. CDS On-Line will allow users to access the division's services. On-line help is available for those who need assistance.

Cooperative Education and Internships

The Cooperative Education Program provides students with an experiential and applications approach to education. Through cooperative education, students gain academically integrated work experience that is related to their degree.

Qualified master's and doctoral students, in some cases, gain salaried professional experience while they earn their degrees. Students may be eligible to participate after completing one academic semester.

Co-op work experiences are concurrent or alternate with full- or part-time graduate study. During placement periods students are enrolled in the Co-op Work Experience course or a pre-approved co-op course substitute in their major department. Co-op Work Experience periods are not limited to academic semesters. Students may begin work in the second semester of attendance at NJIT.

All co-op student participants must be able to produce U.S. employment authorization. Immigration and Naturalization Service (INS) regulations require students with F-1 visas to be in the United States for nine consecutive months before they can be placed in co-op employment. International students become eligible to apply during their second semester of study. They must secure employment authorization by the University's Office of International Students and Faculty before beginning a co-op work experience. There are additional restrictions on co-op employment for students on financial support or involved with research activity and thesis or dissertation work. The Office of Graduate Studies may be consulted about policy issues.

BS/MS Program

This accelerated dual degree program permits undergraduates to earn credits toward a master's degree. Students take six credits of graduate course work in their senior year. These credits are counted both towards credit for a bachelor's degree and for a master's degree.

Full-time undergraduate students become eligible to apply after they complete at least five courses in their major, and have maintained a GPA of 3.0 or better. Applicants must fulfill all university requirements for admission to graduate programs. Honor students who have completed at least five courses in their majors are accepted into the program, upon the submission of a graduate study application.

Graduate study may be completed full- or part-time.

BS/MS students may become eligible for a graduate assistantship. All university requirements for receiving financial support must be satisfied. Refer to the BS/MS Fellowships section under "Financial Support" or contact the Office of Graduate Studies about this or other opportunities.

Information and applications can be obtained from the Office of Cooperative Education and Internships, (201) 596-3100.

Career Planning and Placement

The Office of Career Planning and Placement offers career planning workshops, access to the Career Resource Center, career counseling, and on-campus recruitment by a wide range of prospective employers. In addition, the office maintains full-time job listings. SIGI +, a computerized career search instrument, and company information are located in the Career Resource Center. The center is open Monday through Thursday, 8:30 a.m. to 6 p.m., and Fridays, 8:30 a.m. to 4:30 p.m.

For more information, contact the Office of Career Planning and Placement, (201) 596-3273.

Community and Public Service

Graduate students may also receive financial support through participation in the NJIT Service Corps. Through a wide variety of experiential learning activities, students link classroom theory and concepts with practical application, contribute their expertise and develop leadership, decision-making and interpersonal skills through involvement with non-profit and governmental agencies and community-based organizations.

- **Federal Work Study:** off-campus employment that is course- and major-related in non-profit and governmental agencies and community-based organizations for eligible Federal Work Study students.
- **Housing Scholars:** merit-based, competitive full-time summer employment in community-based organizations that design and develop plans for affordable housing projects around the state. *Civil Engineering, Management, Computer Science, and Computer Engineering* majors who are U.S. citizens or permanent residents, who have completed 6 credits of graduate study, are in good academic standing, satisfy all other university requirements for financial support and are approved by their department's co-op advisor are eligible to apply. *Architecture* students may apply after completing 14 credits of first-year required graduate courses having maintained a cumulative 3.25 GPA. However, participation cannot begin until 28 credits are completed.
- **Service Learning:** students who register for classes that include a community Service Learning option or who register for faculty-monitored independent study that includes a community Service Learning component are eligible to receive a $25 Community Service Merit Award upon completion of the project.

For more information, contact the Office of Community and Public Service, Weston Hall, Room 200, (201) 596-5735.

Alumni Career Services

Alumni of NJIT graduate or undergraduate programs have access to a variety of career assistance services and programs provided by the Division of Career Development Services' Alumni Career Services program. Whether interested in changing careers or currently out of work, NJIT connections are valuable and offer a good place to begin a personal career search. Alumni can take advantage of these services: individual career counseling, the Career Resource Center, full- and part-time employment listings, bi-weekly support groups, computerized bulletin board listing experienced-level job openings, direct access to job postings on the Internet, alumni mentors offering career advice and employment leads, and career-related workshops such as resume writing, interviewing skills, networking, and job search strategies.

Student Services

The Dean of Student Services administers and coordinates the activities of the Student Services Division including the Hazell Center, the Counseling Center, Health Services, Residence Life, the University Learning Center, the Educational Opportunity Program, the Student Support Services Program, the University Research Experience. Special services for evening and disabled students are provided. The office also is the liaison for Food Services, The Pub, and the university bookstore.

The office is located on the third floor of Eberhardt Hall Room 33. The phone number is (201) 596-3466/3470.

The Hazell Center

The Hazell Center is the hub of cultural, educational, and social activities for the NJIT community. The Hazell Center staff strives to provide students, faculty, and staff with a relaxing environment where they can enjoy a meal, study, watch a film, play a variety of games, participate in the many activities offered, or just socialize with friends. The Offices of Student Activities, Greek Life, Women's Center, and Registar are located within the building. The center also houses a wide variety of student clubs and organizations including the Student Senate, Graduate Student Association (GSA), Student Activities Council (SAC), college newspaper (Vector), yearbook (Nucleus), and radio station (WJTB). Over fifty student-run cultural, professional, special interest, and social clubs and organizations share office space in the Hazell Center.

On the lower level of the center is a recreation area with bowling, billiards, table tennis, and video games. A variety of tournaments are offered each semester. The bookstore and student organization offices, including WJTB, are also located on the lower level. The main level of the center houses the Cafeteria and Pub, the Information Desk, and the offices of the Director of the Hazell Center, Assistant Director for Greek Life, and the Reservation Manager. The third floor of the center houses the offices of the Registrar, Student Activities, the Women's Center and several student organizations, This floor also contains the Ballroom, which is used for a variety of large events, several meeting rooms, an art gallery, and the Faculty/Staff Dining Room.

The Hazell Center Information Desk personnel provide information about the campus, community events, and public transportation. The Information Desk also has the university telephone directory, lost-and-found, campus maps, discount tickets for Broadway shows, postage stamps and mail service. Two computers also are provided for students to check class schedules, grades, and registration information. The Hazell Center Office also provides fax service for a nominal charge. The phone number for the Information Desk is (201) 596-3605.

The Constance A. Murray Women's Center

The Constance A. Murray Women's Center works to create a hospitable environment for all women at NJIT. Located on the second floor of the Hazell Center, the women's center offers a wide range of resources, including a multi-media library, computer workstations, and access to a World Wide Web database about women in technology. The center contains space for small group meetings, study, tutoring, and research. It provides a forum for women to discuss matters of mutual concern, including issues related to the academic and social environment at NJIT. It sponsors programs and events especially designed to facilitate mentoring and career networking among women. The center also supports research about women and technology and fosters efforts to explore the continued integration of gender into the curriculum. The lounge/study area is open to all members of the NJIT community daily, Monday through Friday.

International Students

The Office of International Students and Faculty offers numerous services and programs to aid students in their adjustment to NJIT. Because of ever-changing immigration regulations that affect the status of students, all international students holding nonimmigrant visas (especially F and J visas) should report to the office as soon as possible after their arrival. F-1 and J-1 students must maintain full-time registration (12 credits per semester is defined as full-time, except for special cases as defined by the Office of Graduate Studies or the Office of Student Services). Students on dependent visas (such as F-2, J-2 and H-4) should consult with the Office of International Students and Faculty if change in status or full-time study is contemplated. The office is located in Eberhardt Hall Room B10. The phone number is (201) 596-2451.

Students with Disabilities

The Counseling Center provides counseling and coordinates special support services for students with disabilities. These may include general information; academic accommodations such as special testing arrangements, readers or note takers; and liaison with faculty, staff and other agencies. The Department of Mechanical and Industrial Engineering maintains a Macro Lab facility which is open to students who want to modify equipment or facilities to make them accessible to students with disabilities. A Kurzweil reading machine and the visual tech machine are in the Macro Lab for the use of blind, other visually impaired, and learning disabled students.

The Counseling Center is on the third floor of Eberhardt Hall, Room 37E, and is open from 8 a.m. to 6:00 p.m., Monday through Thursday and until 5 p.m. on Friday. The phone number is (201) 596-3414.

Immunizations

The State of New Jersey and NJIT require all students to supply valid records of immunization against vaccine-preventable diseases, e.g., measles, mumps. If documentation is unavailable then re-immunization is required. Contact the Office of Health Services for further information.

Health Insurance

The State of New Jersey and NJIT require all students enrolled full-time and all international students to maintain health insurance coverage that provides basic hospital and medical benefits. International students with J-1 visa status must be covered by an insurance package as specified by the U.S. Information Agency, which generally exceeds NJIT's plan coverage. Further information about required coverage and/or enrollment can be obtained from the Office of International Students and Faculty. Coverage must be maintained throughout the student's enrollment. Insurance may be provided by the student or may be purchased through the university. Students may waive participation in the NJIT plan for the full academic year. To waive insurance, the student must complete a waiver form and submit it to Health Services within 30 days of the beginning of the semester. Waiver forms and insurance brochures are available in the offices of Health Services and the Dean of Student Services.

Part-time students also may purchase health insurance through NJIT within 30 days of the beginning of the fall and spring semesters. Insurance also may be purchased for dependents.

Health Services

To function well in a college setting, a student must be physically and mentally healthy. Good health, defined as physical, social, and emotional well-being is a factor influencing the academic success of any student. To ensure the good health of our students, the Office of Health Services provides primary health care to all enrolled students who have submitted a completed medical examination form.

Services offered to eligible students include the assessment and treatment of health problems and injuries, laboratory tests, health counselling and education. Referrals are made to area hospitals, physicians and other resources when necessary.

The office also coordinates mandatory immunization requirements which apply to all students. Information on immunization requirements is available at the Office of Health Services.

The office is open Monday through Friday, 8:30 a.m. to 4:30 p.m. during fall and spring semesters. Limited summer hours are available by appointment only. Physicians are available for consultation in the student health services office by appointment. Health services staff may be reached at (201) 596-3621.

Counseling Center

The Counseling Center, staffed by experienced psychologists and counselors, is available to any student seeking confidential personal or career counseling. In addition to the professional counseling staff, a psychiatrist is available for consultation as needed. The Counseling Center conducts various group workshops, maintains a library of career and graduate school information, coordinates services for students with disabilities, and administers supportive testing. Students are welcome to come in and browse through the informational materials or to speak with a counselor. Counseling services are also available to evening students who may be experiencing stress from academic, personal, family or employment responsibilities. The Center is on the third floor of Eberhardt Hall, Room 37, and is open from 8 a.m. to 6:00 p.m., Monday through Thursday and until 5 p.m. on Friday. The phone number is (201) 596-3414.

Stop-In Center

The Stop-In Center, staffed by trained student-counselors, provides on-the-spot information and assistance about all aspects of college life. Peer counselors are prepared to talk with fellow students about any questions or concerns—academic or personal—as well as provide general information. If they are unable to resolve a problem directly, they refer students to the person or office that can. No appointment is necessary and students are invited to stop by (downstairs in the Hazell Center, Room 124) and become familiar with the staff and services available. The phone number is (201) 596-3422, 3421 and the Stop-In Center is open weekdays Monday-Thursday from 10 a.m. to 6 p.m.; Fridays to 4 p.m.

Residence Life

NJIT provides on-campus housing for undergraduate and graduate students. The university provides full-time professional and student staff to oversee residence hall operations.

Students may apply for on-campus housing after being accepted for admission. Residence hall contracts are for the entire academic year. Housing space is allocated on a point system that weighs commuting time and class standing. However, a number of spaces are reserved for new students each year.

Each residence hall provides PC connectivity to on-campus academic computing resources and the Internet. A fee is charged per semester for those who desire connectivity service.

Freshmen are required to live in Redwood Hall, which houses 210 students. A special floor has been reserved for Honors College students. Oak Residence Hall serves 265 students. The eight-story apartment building accommodates mostly upper-division and graduate students. There are 12-month contracts available for graduate students. Cypress Residence Hall is an eight-story building accommodating 420 upper division students in two-room suites. Each room houses two students.

Laurel Hall is under construction with occupancy planned for September 1997. It accommodates 300 upper-division students in a combination of single and double bedrooms in suites of three to four students. Each suite has a common vestibule and bathroom.

All four residential buildings are fully secured, furnished and air-conditioned. Desk attendants are on duty 24 hours a day.

Students who are accepted for admission to NJIT will receive information from the Office of Residence Life describing the procedure for applying for space in the residence halls.

Evening Students

Staff from the Office of the Dean of Student Services is available from 4:30 to 6:30 p.m., Monday through Thursday, at the Hazell Center to provide advisement and needed information to evening students.

The Counseling Center is open to evening students until 6:00 p.m., Monday through Thursday, offering confidential professional counseling to adult students who face stress from academic, personal or employment responsibilities.

Many other offices may remain open after regular hours to assist graduate students taking evening courses. Students should contact individual offices to determine availability.

Food Services

Two dining facilities for students are located in the Hazell Center. The student cafeteria serves breakfast, lunch and dinner. The Pub offers sandwiches and snacks, and, to those over 21 years of age, beer and wine.

A Look at Student Life

The extracurricular programs at New Jersey Institute of Technology span a wide range of interests from sports to professional societies.

NJIT has an extensive intercollegiate sports program. Men's sports are baseball, basketball, bowling, cross country, fencing, golf, judo, skiing, soccer, tennis, and volleyball. Women's sports include basketball, cross country, fencing, judo, skiing, softball, tennis, and volleyball. The intramural program includes all sports available at the intercollegiate team level plus track and field, racquetball, flag football, badminton, softball, and archery.

There are 15 social fraternities, most with residential facilities, and six sororities, 15 honor societies, and 12 professional recognition societies. The latter include Tau Alpha Pi, Phi Eta Sigma, Tau Beta Pi, Sigma Xi, Alpha Epsilon Lambda and the American Chemical Society, the American Institute of Aeronautics and Astronautics, the Society for Technology, the Society of Women Engineers and the Society for Advancement of Management, to name a few. There is an active professional society for almost every major field of study offered by the university.

The Student Senate administers a wide range of programs through the Student Activities Council, various Honors societies, and the Cabinet for Professional Societies and Cultural Organizations. Some of these activities include chess, scuba diving, mountain climbing, the "Vector" newspaper, the "Nucleus" yearbook, ham radio, photography, theater, and radio broadcasting. Graduate students also enjoy participating in the NJIT chapter of Pugwash USA and Computer Club 2 (YACC2). NJIT's close proximity to New York City allows students to take advantage of the recreational and cultural life of the city. There are frequent distributions of discount tickets to shows, museums, concerts, and sports events. The Cycling Club, Outing Club, Ski Club and Student Activities Council follow their various interests on weekend trips throughout the Northeastern United States.

And there's the Hazell Center, where students gather to eat, plan programs and activities, socialize, work on publications, bowl, shoot pool, watch movies, play chess, or just relax.

NJIT provides an environment in which students may learn, not only in the classrooms and labs but on the playing field; not only from their faculty but from each other.

Staff from the Office of the Dean of Student Services is available from 5 p.m. to 6 p.m. Tuesday through Thursday, at the Hazell Center to provide information to evening students. Quarterly throughout the year, evening students are mailed a schedule of special events and academic workshops.

The Counseling Center is open to evening students until 6 p.m., Tuesday through Thursday to provide counseling, psychological services or referral for adult students who face stress from academic, personal or employment responsibilities.

Graduate Student Association

The Graduate Student Association was founded in 1983 to promote the interests of graduate students, enhance program quality, foster student-faculty communication, and provide for the needs of advanced degree students.

All students currently enrolled in NJIT graduate degree programs and paying the Graduate Student Association fee are members of GSA. Each degree program is represented on the GSA Council by a current graduate student and an alternate. Students interested in serving on the council or learning more about the GSA should contact the GSA office (201) 596-2993 or the Office of Graduate Studies (201) 596-3462. The Dean of Graduate studies serves advisor to GSA.

Graduate Honor and Professional Societies

Alpha Epsilon Lambda Honor Society

The Sigma Chapter of Alpha Epsilon Lambda, the National Honor Society for Graduate and Professional School students, was established in 1995 at NJIT and is the first chapter in New Jersey. Membership is based on standards of scholarship, leadership and character, and is by invitation. Contact the Dean of Graduate Studies (201) 596-3462 for more information.

Other Honor and Professional Societies

Each program offering graduate degrees at NJIT will have information about honor and professional societies open to graduate students in particular disciplines. Contact the Dean of the appropriate school or college or the Dean of Graduate Studies for further information.

Physical Education and Athletics

The Division of Physical Education and Athletics encourages students to develop individual physical skills that can be utilized throughout life, and provides a variety of programs that will meet the diverse needs and interests of the NJIT community. These include programs of skills instruction, intramural and intercollegiate competition, sports clubs, and open recreation.

The Entwisle Physical Education Building houses a swimming pool; locker rooms; Fleisher fitness center with a 1/16-mile indoor track; an athletic training room; dance, exercise and fencing areas; conference and audio/visual rooms; four racquet sport courts; and three gymnasia. Lubetkin Field is a multi-purpose, lighted recreational area with a regulation soccer field, fields for softball and baseball, and a jogging area. There are four, lighted tennis courts behind the Physical Education Building. Recreational areas are open from 7 a.m. to 11 p.m. Monday through Friday, from 9 a.m. to 3 p.m. on Saturdays, and from 3 p.m. to 9 p.m. on Sundays. For information contact the division office in the Physical Education Building. The phone number is (201) 596-3636.

Admissions

Every application for admission is processed through the Office of University Admissions and is reviewed by the Graduate Admissions Committee. Candidates will only be notified by mail of their admission status. Admission decisions cannot be communicated by telephone, FAX, in-person or to third parties.

For admissions information contact:
Office of University Admissions
University Heights
New Jersey Institute of Technology
Newark, New Jersey 07102
(201) 596-3300, fax (201) 596-3461, e-mail: admissions@NJIT.edu
For on-line application for admission, see NJIT on the Internet: http://www.njit.edu

Test Requirements

Graduate Record Examination (GRE) and Graduate Management Admissions Test (GMAT) The GRE (General Section) is required of all applicants to doctoral programs, all applicants seeking financial support, and all applicants whose most recent degree was awarded from an institution outside of the United States. Specific master's programs: applied chemistry, architecture, chemical engineering, electrical engineering (full-time), environmental science (full-time), environmental policy studies (verbal, quantitative only), applied physics, infrastructure planning, interdisciplinary studies, telecommunications, professional and technical communication, require all applicants to provide GRE scores. It is highly recommended for all other programs.

The GMAT is required for all applicants to the School of Industrial Management.

For further information about taking these examinations, contact: Educational Testing Service, P.O. Box 592, Princeton, New Jersey 08541 (Phone 609-771-7670 8:30 a.m. to 9:30 p.m.).

Test of English as a Foreign Language (TOEFL) International students applying to a doctoral program must show a TOEFL score of at least 550. International students applying to master's programs with TOEFL scores between 500 and 525 may be considered for admission, provided they attend and satisfactorily complete, in the summer immediately before the fall semester, an intensive English language course. Applicants with scores below 500 are not considered for admission.

For further details about TOEFL and NJIT's English as a Second Language course requirements, see "International Students and TOEFL," page 20.

■ MASTER'S DEGREE PROGRAMS

Master's degree programs provide advanced education needed by professionals in an era of rapidly expanding technology and normally require more specialization in the academic discipline of the student's bachelor's degree. A student wishing to change fields may be admitted to a program by satisfactorily completing appropriate undergraduate and/or graduate prerequisites in addition to the normal graduate degree requirements of the department.

Admissions Requirements for Master's Study

Applicants for admission to graduate study must have completed an undergraduate program accredited in the United States or its equivalent and demonstrate superior academic achievement in an appropriate discipline. Students are expected to have placed in the top half of their graduating class and department and to have achieved a cumulative grade-point average no lower than 2.8 on a 4.0 scale. Individual departments may impose more stringent requirements. Applicants with undergraduate degrees in engineering technology must have ranked in the top quarter of their class and have a cumulative grade point average of at least 3.0.

All applicants should submit supplementary evidence of their potential for successful graduate work. Letters of recommendation, Graduate Record Examination or Graduate Management Admission Test scores, a publications record, prior research experience, a record of exceptional career development, a statement of the applicant's objectives, interests, and professional experience are examples of appropriate supplementary evidence.

Graduates of European Universities must hold a first or second class (division one) degree.

Graduates of Universities in Taiwan, Korea, People's Republic of China must have a bachelor's degree equivalent to one in the United States and cumulative grade record of at least 70%.

Graduates of Indian Universities must hold a first class degree.

Bridge Program Students who seek graduate degrees in an academic discipline different from the discipline in which they received their baccalaureate degree may be required to take additional courses. The program of courses will be individually-designed in consultation with their graduate advisor. They must be completed before 9 credits of graduate degree courses are earned. Bridge courses are not counted as degree credits but do count in graduate GPA calculations if the course is numbered 500 or above.

Admissions Procedures

An Application for Admission to Graduate Study form may be obtained from the Office of University Admissions. A non-refundable fee of $35 must accompany the application. Applications may be deferred for one semester for a delay in admission without incurring another $35 fee. Official transcripts from all colleges and universities previously attended are required. To be accepted as official, transcripts must be sent directly to the Office of University Admissions by the institutions concerned. Applications for Fall (September) admission must be received by June 5; for Spring (January) admission by November 5. Applications for financial support have earlier deadlines. Supporting documents must also reach the Office of University Admissions by the above dates. Incomplete applications or applications received after these dates will normally be processed for the following semester.

Program Transfers Students who wish to transfer from one master's degree program at NJIT to another at NJIT must complete an application for admission to the new program and provide appropriate supporting materials. Courses taken in one program are not necessarily transferable to another, nor may credits be applied to more than one degree, except as provided by the MS/MS program.

■ DOCTOR OF PHILOSOPHY PROGRAMS

New Jersey Institute of Technology offers doctoral programs to fill society's need for creative research scientists and engineers. For a complete list of doctoral programs see pages 37 through 82 of this catalog.

Admissions Requirements for Doctoral Study

Applicants are required to have an appropriate academic background as described in the degree program section of this catalog and a GPA of at least 3.5 on a 4.0 scale in prior study. GRE scores are required for admission to all doctoral programs. International applicants must show a TOEFL score of at least 550. Individual programs may establish additional or more stringent requirements.

An applicant who wishes to pursue a doctoral degree in a field different from that of previous study, and who is otherwise qualified, may establish eligibility by satisfactorily completing a program of study recommended by the department in which they seek admission.

Admissions Procedures

Admissions procedures are the same as for a master's degree. In addition, three letters of recommendation are required from individuals who can best judge the applicant's ability to pursue independent research and complete a doctoral program.

■ DOCTOR OF PHILOSOPHY PROGRAMS: COOPERATING UNIVERSITIES

The university cooperates with other universities in Newark in operating and developing doctoral programs of mutual interest. NJIT coordinates the Information Systems specialization of the Ph.D. program in management offered by Rutgers-Newark. NJIT faculty supervise Rutgers doctoral students in this program and in the Ph.D. program in Chemistry offered by Rutgers-Newark. Admissions for the Ph.D. programs in Management and Chemistry are handled by Rutgers-Newark.

The university also participates in unique offerings of joint doctoral programs with Rutgers-Newark and the University of Medicine and Dentistry of New Jersey. Students may apply and be admitted through either university. Current or planned programs that lead to joint diplomas are Applied Physics and Mathematical Sciences with Rutgers-Newark and Biomedical Informatics with the University of Medicine and Dentistry of New Jersey.

■ INDUSTRY COLLABORATIVE DOCTOR OF PHILOSOPHY

This Ph.D. program is specially designed to take advantage of collaboration with industry. It is for mid-career scientists and engineers who want to pursue doctoral studies while employed full-time. Academic requirements are the same as for other university doctoral programs.

To participate in the program, students must be nominated by their employer. These nominations serve as letters of recommendation in the admissions process. In addition to nominating students, employers must commit to a proposed area of research, identify research facilities, and appoint one senior researcher or manager to serve on the student's dissertation committee.

Students nominated by employers must meet university requirements for admission to doctoral programs. Prior industrial research activity, publications, and honors will be evaluated in addition to traditional academic criteria.

Doctoral students are expected to have been employed by the employer for at least five years, and to have completed a related master's degree. They are expected to continue employment until they complete all degree requirements. Annual reviews of progress will be conducted. Students may do dissertation research at their employer's facilities. Dissertation research can be derived either from activities and interests of the student, or of the employer.

Dissertation research must satisfy university policies. Residency requirements are defined by the student's dissertation committee. It is expected that time will be provided by the employer to permit at least one year's concentrated effort on dissertation research. Seminar requirements are also defined by the dissertation committee and may include presentations or attendance at professional society meetings. Course requirements are based on previous research activities of the student. Dissertation research is expected to investigate or develop an original contribution to science and technology. Research may be experimental, analytical, applied, or theoretical provided that it satisfies all criteria set by the dissertation committee.

Employers who have proprietary interest in dissertation research including patent, copyright, and technology transfer rights are expected to execute formal agreements with the university before research begins.

■ DEGREE OF ENGINEER

NJIT offers specially designed Degree of Engineer programs for the practicing professional engineer in chemical, civil, electrical, and mechanical engineering. Programs emphasize the application of new knowledge to engineering practice.

Admissions Requirements

Minimum requirements for admission are a master's degree in chemical, civil, electrical or mechanical engineering and at least three years of professional engineering experience in the field in which the degree is sought. A GPA of at least 3.0 in previous graduate studies is required for admission.

Admissions Procedures

Admissions procedures for the Degree of Engineer are the same as for a master's degree. In addition, letters of recommendation are required from:

- Chairperson or advisor of the department of major study in the applicant's undergraduate school.
- Chairperson or advisor of the department of major study that conferred the applicant's master's degree.
- Employer (or employers) describing in detail the applicant's professional engineering experience.

Admission Classifications

DEGREE (MATRICULATED) STUDENTS

Regular Admission

Applicants who meet NJIT standards and have an appropriate academic background will be offered regular admission as degree-seeking (matriculated) students.

Conditional Admission

NJIT expects applicants to have a superior academic record, but recognizes that interest, creativity, maturity, and motivation are also important. Conditional admission to the university may be granted to applicants who do not have the appropriate academic background required for a particular degree program, but who have an academic record that meets NJIT's scholastic standards.

Once granted conditional admission, students must complete conditional or bridge courses specified by the university within their first two semesters. Such courses may be at either the undergraduate or graduate level and are NOT counted as degree credits although all graduate courses are calculated in the GPA. Students must attain grades specified by the university and are not permitted to take more than 9 credits that count as graduate degree credits at NJIT before meeting the terms of conditional admission. Failure to meet these conditions may result in dismissal from the university.

Contingent Admission

Students who apply for admission to graduate programs before completing their bachelor's degree, and whose records demonstrate superior academic achievement, may be offered admission to NJIT contingent on their showing proof of receiving an undergraduate degree. Such students must show proof of graduation before being permitted to enroll in a graduate program.

Change of Major

Students are admitted to one graduate degree program and not to the university as a whole. Students who wish to change major on arrival at NJIT must file an application for the new program and remain in the original program until the application is approved. There is no guarantee or requirement that the new application will be successful.

Students who feel their new application may be successful may request approval from the Office of University Admissions to take up to 9 credits in their new major. Additional approval from the graduate advisors of the original and new major and the Dean of Graduate Studies is required.

Those on support may be liable to loss of support from the original department and cancellation of a current award. International students and others who must be full-time will still be required to have a 12-credit registration.

Change of Level

Students who wish to change current degree level must file an application for admission to the new degree level. There is no requirement or guarantee that the application will be successful. Students who wish to drop down to a master's or degree of engineer program from a doctoral program should be aware of the impact of this action on current and future financial support. Students who wish to raise their level from a master's to a doctoral program should be aware of any impact on incomplete master's theses or projects.

NON-DEGREE (NON-MATRICULATED) STUDENTS

Students who wish to take graduate courses without seeking a degree (non-matriculated status) should contact the Office of University Admissions for a Non-Degree Application Form.

Non-matriculated students may be permitted to take a maximum of 9 graduate-level courses over three registration periods, except students seeking a graduate certificate. These students may take a maximum of 12 graduate-level credits over four registration periods. Students wishing to take credits beyond these limits must apply and be accepted to a degree program as a matriculated student.

Academically qualified students who do not desire to enter degree programs may enroll for certain individual graduate courses. Such students must present transcripts of previous academic work or other appropriate evidence at each registration in order to indicate adequate preparation for the course work involved. If approved by the Office of University Admissions, registration will be permitted if space is available. Permission to enroll as a non-matriculated student does not imply eventual admission to a degree program.

Graduate Certificate Programs

NJIT offers clusters of courses in concentrated areas for students wishing to obtain a certificate of completion. In general, these require completion of 12 credits at the graduate level. Students in these programs are considered to be non-matriculated students for the duration of the certificate program.

Students Matriculated at Other Universities

Graduate degree students at other colleges or universities may take courses for credit at NJIT for transfer back to their home institution. In addition to satisfying the course prerequisites, students must furnish a letter of approval from an appropriate administrative officer of their home institution.

NJIT Undergraduates

NJIT undergraduates may register for graduate courses, 500- or 600-level, with written approval from both their undergraduate advisor and from the graduate advisor in the department in which the course is taught.

NJIT students in the BS/MS or University Scholars program are required to take at least 6 graduate-level credits while undergraduates to satisfy program requirements. Additional graduate credits may be taken up to a maximum of 9 additional, with approval by the two advisors. Further definition of these programs is pending approval.

Rejected Applicants

Students whose application for admission to a degree program is unsuccessful are not permitted to register as non-matriculated students.

International Students

International students on F-1 and J-1 visas are not permitted to register as non-matriculated students. Students on other visas should consult the Office of University Admissions regarding non-matriculated status.

Auditors

Students who wish to attend courses for which they are qualified, but who do not wish to be graded in the course, may be permitted to enroll as auditors. Registration will be approved only after a review of credentials by the Office of University Admissions and only if space is available. A notation signifying that the course was audited will be made on the student's record, but no credit will be granted for the course. Students who wish to audit a course must state their intention at the time of registration. A change to, or from, auditor status is not permitted once a semester has begun. Students who audit a course are required to pay full tuition and fees. There is no tuition remission for courses that are audited. Audited courses do not count in determining full-time status for students who must maintain full-time status.

TRANSFER STUDENTS

Students enrolled in graduate programs at other institutions may apply for transfer to NJIT by completing the normal admission procedure. In addition, international students wishing to transfer from other educational institutions in the United States must:

- Demonstrate a cumulative grade-point average of at least 3.0 in graduate courses taken at other U.S. educational institutions;
- Complete the required immigration procedures for transfer; and
- Be eligible for admission to the NJIT program of their choice.

Transfer students may apply for credit for courses taken at other U.S. educational institutions by following procedures outlined in the "Transfer of Credit" section.

INTERNATIONAL STUDENTS AND TOEFL

New Jersey Institute of Technology welcomes applications from international students with records of superior academic achievement. In addition to the procedures stated below, international students are required to provide evidence of English language proficiency by submitting Test of English as a Foreign Language (TOEFL) examination scores. Information concerning TOEFL may be obtained from TOEFL, Educational Testing Service, Princeton, New Jersey 08540.

International students entering NJIT are required to take an ESL (English as a Second Language) course if their TOEFL scores are between 525 and 550. Students must satisfactorily complete the ESL course in their first semester. Students may be exempted from this requirement by the director of the ESL program, or if they pass the NJIT English Test, which is given at the beginning of each semester. The test has three parts: listening, grammar, and writing. The exemption test must be taken prior to the first semester at NJIT.

Students with TOEFL scores of 550 or better are not required to take an ESL course but are encouraged to improve their English-language skills by doing so voluntarily.

All ESL courses are graded on an S/U (Satisfactory/Unsatisfactory) basis. The course credits count towards the 12 credits needed for full-time status; however, the credits do not count towards credits needed for graduate degrees.

Students Who Seek Financial Support

Those seeking financial support from NJIT at the time of admission will be required to achieve a TOEFL score of at least 550.

INTERNATIONAL STUDENT FINANCIAL STATEMENT

In accordance with U.S. Immigration and Naturalization Service requirements, international students must also submit to the Office of University Admissions an International Student Financial Statement to demonstrate financial resources sufficient to meet the academic and living costs of their anticipated stay at the university. Forms for this purpose are included with admission materials; additional copies may be obtained from the Office of University Admissions. International students should note that they will be required to pay non-resident tuition rates. Immigration papers (e.g., I-20, IAP-66, etc.) will NOT be issued until the International Student Financial Statement is on file with the Office of University Admissions.

Academic Credential Equivalents for International Students

To be eligible for admission to graduate study at NJIT, international students must have the following minimum academic qualifications. Undergraduate degrees must be equivalent to the typical four-year program in the United States. NJIT is working with a number of countries and universities to provide a transition from two- and three-year degree programs to baccalaureate and later graduate study.

Argentina	Licenciatura
Bahamas	Honors Bachelor's degree
Barbados	Honors Bachelor's degree
Bolivia	Licenciatura
Brazil	Bacharel or Licenciado
Canada	Honors Bachelor's degree or the equivalent
Chile	Bachillerato, Licenciatura or Título of at least four-year duration
People's Republic of China	Bachelor's degree
Colombia	Licenciatura or Título
Dominican Republic	Licenciatura of at least four-year duration

Ecuador	Licenciatura or Título
Egypt	Bachelor's degree
El Salvador	Licenciatura
France	Maîtrise or equivalent
Germany	Diplomgrad, Staatsexamen, or Magister Artium
Greece	Ptychion
Guatemala	Licenciatura
Haiti	Diplôme d'Etudes Supérieures or Licence of at least four-year duration
Honduras	Licenciatura of at least four-year duration
Hong Kong	Honors Bachelor's degree
India	Bachelor's degree in Engineering or Architecture, Master's degree in other subjects
Indonesia	Sarjana or Insinyur
Iraq	Bachelor's degree
Israel	Bachelor's degree
Italy	Laurea
Jamaica	Honors Bachelor's degree
Japan	Bachelor's degree
Jordan	Bachelor's degree
Korea	Bachelor's degree (Taehak Taehakkyo)
Kuwait	Bachelor's degree
Lebanon	Bachelor's degree, Licence of at least four-year duration, or Maîtrise
Libya	Bachelor's degree
Malaysia	Bachelor's degree
Mexico	Licenciatura of at least four-year duration
Morocco	Licence or Ingénieur d'État
Netherlands	Doctorandus, Ingénieur, or Meester
Nicaragua	Licenciatura
Nigeria	Honors Bachelor's degree
Norway	Cand. Mag.
Pakistan	Bachelor's degree in Engineering or other four-year Bachelor's degree or Master's degree
Panama	Licenciatura
Paraguay	Licenciatura of at least four-year duration
Peru	Bachillerato, Licenciatura, or Profesor from a four-year university program
Philippines	Bachelor's degree
Saudi Arabia	Bachelor's degree
Singapore	Honors Bachelor's degree
Sweden	Filosofie Kandidatexamen or Ekonoexamen
Switzerland	Licence or Diplom of at least a four-year duration
Syria	Licentiate or Bachelor's degree
Rep. of China (Taiwan)	Bachelor's degree
Thailand	Bachelor's degree
Trinidad and Tobago	Honors Bachelor's degree
Turkey	Lisans or Bachelor's degree
United Kingdom	Honors Bachelor's degree
Uruguay	Licenciatura of at least four-year duration
Venezuela	Licenciatura or equivalent

Students from countries whose universities do not provide transcripts, or who experience exceptional difficulty in obtaining transcripts, should contact the Office of University Admissions for special instructions. Students whose credentials cannot be evaluated by the Graduate Admissions Committee will be required to submit a Credential Evaluation Report from an approved agency. For further information, contact World Education Service, Inc., Old Chelsea Station, P.O. Box 745, New York, NY 10011, (212) 460-5644.

Tuition and Fees

New Jersey Institute of Technology reserves the right to increase tuition and fees as required.

Students incur a legal obligation to pay tuition and fees when they register for classes. Unless the Registrar receives written notice by the fifth day of the semester that a student will not be attending classes, the student will be billed for payment.

EXPENSES

The Office of University Admissions estimates full-time students' living expenses independent of tuition and fees for the (nine-month) academic year 1996-1997 to be approximately $7,500. This includes housing, food, books, transportation, and personal expenses for a single student. These are only approximations and are subject to change each year.

HEALTH INSURANCE

Full-time students and all international students must show evidence of existing health insurance, or they will be required to purchase coverage from the university for $130 per academic year. International students must purchase health insurance at full-cost, regardless of the number of credits they are taking. However, International students with fewer than 12 credits should see "Health Insurance" under "Student Services" in this catalog for further information. All students must be registered for a minimum of 3 credits to be able to purchase insurance from the university.

APPLICATION AND SPECIAL FEES

Admissions Application Fee Applications for admission must be accompanied by a nonrefundable fee of $35. Students who wish to change major must file a new application and pay an additional $35 fee.

BS/MS and University Scholars Program Application Fee Applications for participation in these programs must be accompanied by a nonrefundable fee of $35.

Late Payment Fee Students are charged $50 if they do not pay tuition and fees within the period stipulated in payment instructions.

Late Registration Fee Registration is required for each semester. A late registration fee of $50 is required after the deadline specified in registration instructions.

Internet Connectivity Fee Students who live in a university residence hall may choose to have direct connection from their PC to the Internet. A $22 fee is assessed for each semester of service.

Maintaining Registration Fee Students admitted to degree programs who find it necessary to temporarily discontinue their studies, may maintain their enrollment by paying $50 for each semester they do not register for courses. The mechanism for maintaining registration is the notation MR on the registration form.

International students on F-1 and J-1 status may not maintain registration unless they have obtained permission for a Leave of Absence.

Doctoral students in the dissertation stage and master's students in the thesis or project stage of their programs are not permitted to maintain registration by this mechanism and must be enrolled in dissertation, thesis or project credits until completion of the dissertation, thesis or project. Additional tuition and fees may be imposed for failure to be enrolled in dissertation, thesis or project credits as required. Other limitations on MR exist for those in academic difficulty.

If international students must interrupt their studies temporarily, they are required to first consult with the Office of Graduate Studies as well as the Office of International Students and Faculty to obtain permission for a Leave of Absence.

Readmission Application Fee Applications for readmission must be accompanied by a nonrefundable fee of $35.

Transcript Request Fee There is a $3 fee for each copy of a transcript requested. Requests for transcripts are not honored if there is an unpaid balance on the student's account.

Schedule Change Fee A fee of $15 is charged for each schedule change requested after the deadline specified by the Registrar.

Thesis and Dissertation Fees Upon acceptance by the Office of Graduate Studies, a fee of $45 is charged for binding one original and two copies of master's theses; and $90 for binding one original and two copies of doctoral dissertations. Binding fees for additional copies are $15 each for master's theses and $30 for doctoral dissertations (up to five copies total). Arrangements for full publishing and copyright services are handled through the Office of Graduate Studies and by agreement with University Microfilms International.

Commencement Fee A $70 fee is charged when application for graduation is made. If degree requirements are not met for the designated graduation date, the student must refile, and is charged again.

Tuition and Fees 1996-97 (in U.S. dollars)

As of September 1996 the charges for tuition and fees for graduate programs are as follows:

	N.J. Resident	Non-Resident
Full-Time	$3170/semester	$4579/semester
Part-Time	326/credit	451/credit

NOTES: Part-time = 1-11 credits per semester. Full-time = 12-19 credits per semester. More than 19 credits: each credit is paid for in addition to the full-time tuition rate and is charged at the part-time rate.

FEES

Full-Time (fees per semester)	
Registration	$ 60
Academic Facilities	$250
Student Services	51
Graduate Student Association	32
Athletics	19
Health Fee	10
Total	$422
Part-Time (fees per credit)	
Academic Facilities	24
Student Services	6
Graduate Student Association	2
Athletics	2
Total	$ 34
Part-Time (fee per semester)	
Registration	$ 60
Health Fee	10
Total	$ 70
International Student Fee	$15 per semester

International students are charged as non-N.J. residents.

REFUNDS FOR WITHDRAWAL

Tuition—Students who withdraw from NJIT voluntarily, receive a refund of tuition based upon the following schedule, provided that a properly completed withdrawal application has been received by the Registrar's Office. Mere non-attendance does not constitute formal withdrawal.

International students, students on probation, and students receiving financial support *must* have their withdrawal form approved by the Dean of Graduate Studies. Approval is also required for withdrawals that affect full-time status, progress toward a degree, admission requirements, or ESL. The date of withdrawal will be the date upon which the application is received by the Registrar's Office. *Refunds will not be granted for withdrawal applications received after the fifth week.* Applications for withdrawal may be obtained from the Registrar's Office.

The percentage of tuition refunded will be based on the following table:

Receipt of Withdrawal Application	% of Refund
Before the first day of classes	100%
During the first week of the term	100%
During the second week of the term	80%
During the third week of the term	60%
During the fourth week of the term	40%
During the fifth week of the term	20%
During the remainder of the term	0%

This schedule applies only to the regular fall and spring semester. For summer session one class meeting is considered one week.

Fees—Tuition-related fees are refundable during the 100% tuition refund period. Thereafter, these fees are not refundable.

Liability for Charges

A student who registers for a course is liable for all tuition and fees until a properly completed withdrawal notice is received by the Registrar's Office.

Student Residency for Tuition Purposes

Residency status for the purpose of tuition assessment will be made by the university based upon N.J.S.A. 18A:62-4 and New Jersey Administrative Code Title 9. These statutes require that individuals must be legally domiciled in the state for 12 months prior to enrollment to be eligible for in-state tuition rates.

The procedures outlined below will govern the determination of residency status for the purpose of calculating tuition. All students who are not domiciliaries of New Jersey will be assessed out-of-state tuition rates.

Initial Determination of Residency

When an application is submitted for admission to any graduate or undergraduate program the admissions office will determine the applicant's resident status for tuition assessment. This determination will be based upon information supplied by the applicant on the application for admission. Applicants who are not citizens of the United States must complete the non-resident portion of the application and supply documentation of their non-immigrant status.

The university reserves the right to correct any errors in resident status based upon incorrect or insufficient information supplied by the student which directly or by inference leads to an inaccurate tuition assessment. When an error has been identified and corrected, tuition will be recalculated for the terms affected and the student will be held liable for any additional tuition.

Legal Determination of Residence

As set forth in N.J.A.C. 9A:5-1.2, "Persons who have been domiciled within this State for a period of 12 months prior to initial enrollment in a public institution of higher education are presumed to be domiciled in this State for tuition purposes. Persons who have been domiciled within this State for less than 12 months prior to initial enrollment are presumed to be nondomiciliaries for tuition purposes."

The university reserves the right to request the student to have the Internal Revenue Service or the New Jersey Division of Taxation forward tax records to the appropriate university office for review or to request same directly from the student.

An individual who claims to have established a new domicile in New Jersey must show (1) a physical abandonment of the previous domicile, together with an intent not to return to it, and (2) actual presence in New Jersey with the intention of remaining permanently in the state for reasons other than attending school.

An individual from another state or country who has enrolled in any type of educational institution in New Jersey prior to applying to NJIT will be presumed to be in New Jersey primarily for educational purposes and will be presumed not to have established domicile in New Jersey. Although the student may present proof to overcome these presumptions, it must be noted that continued residence in New Jersey during vacation periods or occasional periods of interruption to the course of study does not of itself overcome the presumptions.

THE EFFECTS OF MARRIAGE

A non-resident student who marries a bonafide New Jersey domiciliary assumes the domicile of that spouse for tuition purposes in the term following marriage. The same test for residency will be applied to spouses when marriage is claimed as the basis for domicile.

No change in status will occur when a domiciliary student marries a non-domiciliary.

FOREIGN NATIONALS

International students studying under a non-immigrant status (such as F, J, and all others) may be eligible to pay resident tuition upon receipt of their (green) permanent resident card. In addition to receipt of permanent resident status in the United States, students must comply with the definition of "Domicile" as described in that section of the catalog. Any other non-immigrant alien (H-1, E-1, etc., status) will be classified as a non-resident for the assessment of tuition.

Residency will be determined as of the first term following the admission date on the green card. Applications will not be processed unless a photocopy of both sides of the green card is included with the application. A tuition refund will be issued if the admission date on the green card precedes the start date of the current term.

Residence established solely for the purpose of attending a particular college or university cannot be considered as fulfilling the definition of domicile.

Refugees Students attending NJIT as documented refugees may be eligible to pay resident tuition rates provided they are domiciled in New Jersey and maintain good academic standing. Their status will be reviewed each semester by the Director of Financial Aid.

Political Asylum Students who have been granted political asylum in the United States may be eligible to pay resident tuition rates effective the semester after which asylum has been granted.

Request for a Change of Residency Status

Requests for a change in residency status must be submitted to the Registrar no later than four weeks before the end of the term for which a change in status is sought. A Residency Analysis Form with all supporting affidavits, deemed appropriate by the Registrar pursuant to N.J.A.C. 9A:5-1.1 et seq., must be filed at the time of application. Students who qualify for resident tuition assessment based on the information supplied with their request will have their status changed only for the current and subsequent terms. No adjustments in tuition assessments will be made for prior terms.

Residency Appeals

Appeals on the determination of residency status will be made to the Registrar and will be accepted no later than one month after the date of notification of any such determination. Unresolved appeals will be forwarded to the Assistant Vice President for Academic Affairs: Enrollment Planning. The Vice President will respond to the appeal within thirty working days of receipt of the appeal.

The decision of the Assistant Vice President for Academic Affairs: Enrollment Planning will be final.

Student Responsibilities

Students are responsible for providing relevant and accurate information upon which a residency determination can be made. The burden of proving residency status lies solely upon the student. Moreover, it is considered the obligation of the student to seek advice when in doubt regarding eligibility for in-state tuition assessment. If the student delays or neglects to question eligibility status beyond the period specified above, the student forfeits the right to a residency assessment to which he or she might have been deemed eligible had an appeal been filed at the appropriate time.

Students who are classified as resident students but who become non-residents at any time by virtue of a change of legal residence are required to notify the Registrar immediately.

An independent student loses residency status for instate tuition payment immediately upon abandonment of the New Jersey domicile. Assessment of non-resident tuition charges will take effect the term following the date of abandonment.

Penalties

If a student has obtained or seeks to obtain resident classification by deliberate concealment of facts or misrepresentation of facts or fails to come forward with notification upon becoming a non-resident, he or she is subject to disciplinary action before the university's professional conduct committee.

Factors Considered in Determining Residence for Tuition Assessment

CLASSIFICATION

Students residing in New Jersey for a period of twelve months before first enrolling at a public institution of higher education in the State of New Jersey are presumed to be state residents for tuition purposes.

Students who have been domiciled within this state for less than twelve months prior to the date of enrollment are presumed to be non-residents for the purpose of calculating tuition. Students who assert residency but whose resident status is challenged by the university must prove their domicile according to the following regulations.

DOMICILE

"Domicile" means the place where a person has his or her true, fixed, permanent home and principal living establishment, and to which, whenever he or she is absent, he or she has the intention of returning.

Although actual presence is not necessary to preserve domicile once it has been acquired, a person, if absent from the state, must have the intention of returning to New Jersey in order to remain a domiciliary.

In determining whether domiciliary status has been shown, mere physical presence and the assertion of a declaration of intent to remain in the state may not be sufficient. To assist in determining whether a person is a New Jersey domiciliary, the primary evidence of residency, although not dispositive, is a notarized affidavit setting forth domicile and a copy of New Jersey income tax return substantiating employment in New Jersey as the applicant's primary reason for residing in the state. In the case of dependent students, a copy of the parent's or legal guardian's New Jersey tax return will be required in addition to the affidavit. The following additional items may also be considered: voter registration of the individual in New Jersey; a New Jersey driver's license; New Jersey motor vehicle license and/or a registration or such other information as the university deems acceptable. In unusual circumstances, if primary evidence is not available, the institution may make a determination of New Jersey domicile based exclusively on supplementary evidence; however, supplementary evidence may not be deemed sufficient to justify a determination of domiciliary status.

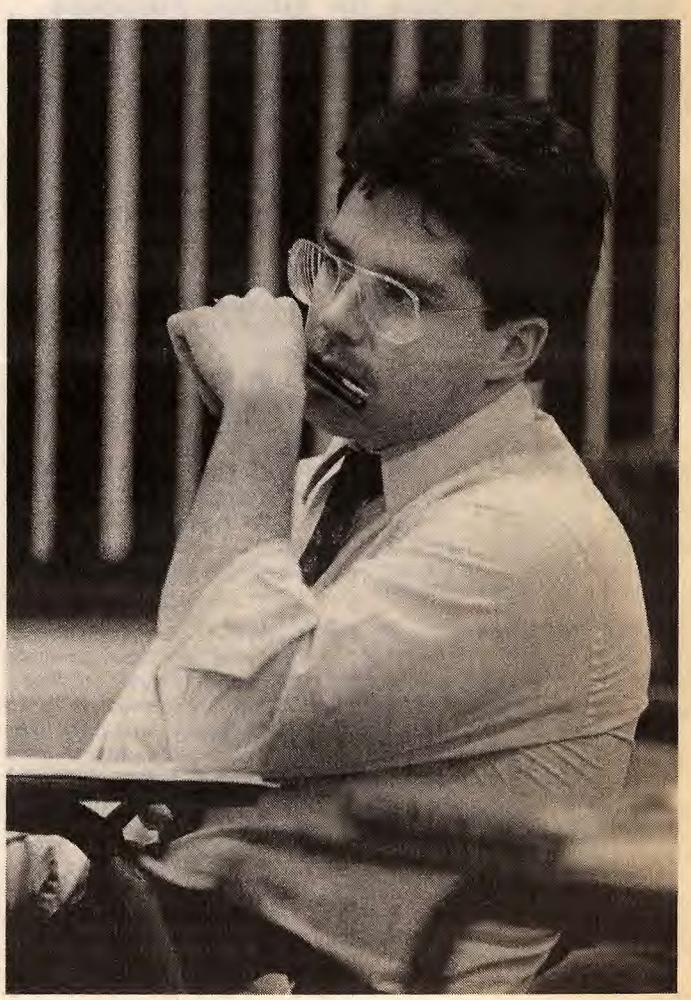
If a student resides with his or her parents or legal guardians for more than six consecutive weeks last or this year, or is dependent upon them for food, clothing, or shelter during the present or prior year, or is claimed, or will be claimed, as a dependent for income tax purposes for the last or current year, the student is deemed to be financially dependent. In such case, the domicile of the individual's parent or legal guardian for the year prior to the term of admission will determine the domicile of the dependent student.

Conversely, if a student has not lived, and will not live, with parents or legal guardians for more than six consecutive weeks during the present or prior year; and has not received and will not receive financial assistance from parents or legal guardians of more than $750 in support of any kind including food, clothing and shelter last year and this year; and has not been claimed as an exemption on parents' or legal guardians' tax return last and this year; and has resources, which should be at least equal to the level of public assistance in the preceding calendar year, the individual is deemed to be financially independent and student's own domicile, for the year prior to the term for which New Jersey domiciliary status is sought, will determine his or her domiciliary status.

PRESENCE IN NEW JERSEY DUE TO MILITARY SERVICE

As a general rule, in the absence of any intention to effect a change of domicile, the domicile of a person is not affected or changed by reason of his or her entry into the military service.

United States military personnel and their dependents who are living in New Jersey shall be regarded as residents of the state for tuition purposes.



Financial Support

Financial Support and Graduate Awards

Various financial support and graduate award options are available to graduate students at NJIT to help pay for studies and expenses. Financial support comes from either NJIT internal funds or from external sources. Eligibility and selection criteria are summarized in the following table. Funds for these are not guaranteed.

Type of Support	Contact	Who is Eligible
Federal Loans	Financial Aid (201) 596-3479	U.S. citizens, permanent residents; full-time or part-time students, based on financial need
Federal Work-Study	Financial Aid (201) 596-3479	U.S. citizens, permanent residents, full-time students, based on position availability
Industry Co-op	Cooperative Education (201) 596-3100	Full-time students, based on position availability; master's only
BS/MS University Scholars	Cooperative Education (201) 596-3100	Participating undergraduate students continuing in NJIT master's programs
Hourly Jobs	Career Planning and Placement (201) 596-3100	U.S. citizens, permanent residents, international students, full-time students, based on position availability
Scholarships, Fellowships, Grants	Graduate Studies (201) 596-3462	Based on funding source, full-time students, often supporting under-represented groups
Assistantships Awards	Graduate Studies (201) 596-3462	Full-time, based on academic merit or priorities and on funds available
Curricular Practical Training	International Students (201) 596-2451	International students, based on INS regulations and industry availability

NJIT AWARDS

Close to 400 teaching, research, and graduate assistantships, based on academic merit, are awarded to qualified full-time students.

Competition for awards is strong. Students are urged to apply no later than March 1 for the fall semester of the following academic year and October 1 for the spring semester of the current academic year. Applications received after these dates may be placed on a waiting list.

All applicants must submit an Application for Graduate Financial Support. Forms are available from the Office of Graduate Studies or the Office of University Admissions. In addition, transcripts of courses already completed, and GRE (General Section) or GMAT scores are required.

Only successful applicants are notified. Teaching and Research Assistantship offers may receive full or partial tuition, an annual stipend or both. Additional funds for the summer may be awarded.

Assistantships

Each year, there are over 300 teaching and research assistantships in academic and research departments, which are funded internally or externally. Teaching assistants conduct recitation, discussion, laboratory, or other sections of elementary or intermediate-undergraduate-level courses, under supervision of permanent faculty. These duties are considered part-time work and typically include six to nine class contact hours per week. Research assistants conduct research under the supervision of NJIT faculty. Non-academic departments also employ students as graduate assistants. Duties range from academic support to day-to-day operation of administrative offices.

Presidential Fellows A limited number of fellowships, with average stipends of $14,400, are offered to outstanding doctoral students. The stipend can be supplemented by residence, research, and summer support. Full tuition support is provided.

Teaching Fellows Teaching Fellows provide services similar to those of an adjunct instructor and their stipends are based on the adjunct salary scale. A maximum of two courses, or six contact hours, per week may be assigned. Tuition remission of 3 credits for each course taught may be awarded in addition to the stipend.

Grader A grader is appointed for part-time service and grades course work under the direction and supervision of a faculty member. Graders may either be hired on an hourly basis through the Office of Career Planning and Placement, or through the Office of Graduate Studies. Compensation is based on hourly rates established for this position. Graders are normally assigned to courses in which the enrollment is unusually high.

Special Awards Special awards for service may be established each year. Students should contact the Office of Graduate Studies for further information.

BS/MS and University Scholars Awards NJIT undergraduates in the BS/MS or University Scholars program may receive one semester of support, depending on availability of funds and student eligibility, if they pursue full-time graduate study at NJIT immediately after completing their undergraduate degrees. Ten hours per week of university service, designated by NJIT, are required for support. In order to receive support, students must have been in the BS/MS or University Scholars program as undergraduates for at least two semesters and have taken at least 6 credits toward their master's degree while undergraduates. A grade of B or better must be earned in these graduate courses. Students in these programs who choose to participate in cooperative education assignments in their first semester after completion of the undergraduate degree are not eligible for these awards.

Non-service Fellowships or Scholarships Private, state, federal, or foundation awards that do not require service to NJIT may supplement service-based awards.

Maximum Stipend Support Levels (9-Month Awards)
Teaching/Research Assistant: master's $8,100, doctoral student $10,800, doctoral candidate $11,700. These levels are reviewed annually.
Graduate Assistant: positions requiring advanced educational skills, $6,750; and positions not requiring advanced educational skills, $6,075

Partial awards are possible. Stipends are paid every other week. Award periods are scheduled for two consecutive 4½-month periods with no gaps between fall and spring award periods.

Summer Support

Depending on availability of funds, students may be eligible for stipends and tuition support for June, July and August. NJIT has two summer award periods, the first covering late May and June, the second covering July and most of August. The split of summer award periods is based on the combination of the semester-based academic calendar used at NJIT and the change over to a new fiscal year on July 1. Students receiving support for a summer award period may not be otherwise employed in these months without approval from the Office of Graduate Studies. Interested students should consult their faculty advisors in March or April.

International Students

International students are eligible only for merit-based NJIT financial support, as indicated above, and NOT for need-based state or federal funds. Private loans, based on financial credit, are available through the Office of Financial Aid. These loans require a co-signer who is a U.S. citizen or permanent resident (holds a green card).

International students may not receive NJIT support or be employed on-campus during periods of practical training. International students must be in status with the Immigration and Naturalization Service (INS) and must attain a TOEFL score of at least 550 to be considered for financial support upon admission. Those with TOEFL scores below 550 are required to attend ESL classes and may be eligible for support after satisfactory completion of the required ESL courses.

INS regulations require that international students attest to having funds sufficient to cover the expense of the entire course of study before they will grant a visa. Students are expected to demonstrate the availability of funds for the duration of studies at NJIT as a requirement for admission to the university.

GOVERNMENT-FUNDED SUPPORT FOR GRADUATE STUDIES

University Research Experience (URE) The State of New Jersey established URE to encourage and support underrepresented groups to engage in undergraduate research and to pursue graduate study on a full-time basis. Contact the URE office for further information, 201-596-6470.

Minority Academic Career Program (MAC) The MAC program supports doctoral students interested in faculty positions in New Jersey. Contact the Office of Graduate Studies for information on this and other state programs.

NSF and NRC Programs The National Science Foundation and the National Research Council support doctoral stipends and tuition. Application deadlines for these programs are one year in advance of anticipated study, usually in early fall. Contact the Office of Graduate Studies for information on these and other federal programs.

NCEA and GEM The National Consortium for Educational Access and the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. support graduate students within industry and academe-based consortia. Contact the Office of Graduate Studies for informaton on these and other industry programs.

Federal Direct Loans and Work-Study Support U.S. citizens and permanent residents are eligible to apply for federal loans through the William D. Ford Federal Direct Loan Program and may be eligible for federal work-study support. All applicants must file the Free Application for Federal Student Aid with the Federal Student Aid Programs Processing Center. For further information about these programs, contact the Office of Financial Aid, 201-596-3479.

TERMS AND CONDITIONS OF AWARDS

Award Selection

All NJIT awards are merit-based and are offered only to academically superior students who meet all selection requirements. Many things are considered in evaluating applications and nominations for NJIT awards. Among these are grade point averages, GRE and GMAT scores, undergraduate and graduate academic performance, educational preparation, TOEFL scores for international students, skill and talent required for available positions, institutional priorities, availability of funds, special skills, and prior experience. TOEFL and ESL requirements are noted in the "International Students and TOEFL" and "Test Requirements" sections of this catalog.

Although there is no minimum eligibility score for the GRE or GMAT, NJIT may establish them for certain awards. For instance, GRE mathematical scores between 700 and 800 typically are expected for awards. Students must take the GRE or GMAT and arrange to have official score reports to be sent to NJIT before they may become eligible to receive awards.

Graduate students who have not already received awards or been offered an award on admission must attain a minimum grade point average of 3.5 for support from internal funds and 3.0 for support from external funds. Any graduate or undergraduate course taken by a student in graduate studies at NJIT is counted in the grade point average (as calculated by the Office of Graduate Studies) for evaluating selection criteria, including courses that were reported or excluded. Grade point averages are checked at the beginning of each support period to verify that awards are warranted. Grade point averages only establish eligibility and neither guarantee or entitle students to receive financial support.

Criteria for support from internal funds are evaluated each year by the Office of Graduate Studies. It reflects both average grade point performance levels and availability of funds. A student who has received support from NJIT funds for one degree cannot receive NJIT support for another degree of the same or lower level or type. Criteria and full details of terms and conditions of awards are available from the Office of Graduate Studies. A handbook of financial support policies and procedures is available.

Need-based support programs administered by the Office of Financial Aid and by the Office of Student Employment have different criteria for selection. These offices should be consulted for further information. Funds distributed for hourly employment through the Office of Student Employment are not considered awards.

Service-Based Awards

A "service-based" award is one which requires that a student perform a service in return for a stipend. The following awards are service-based: *Graduate Assistants, Teaching Assistants, Research Assistants, Presidential Fellows, Teaching Fellows, Graders,* and others as noted.

Terms and Conditions

By accepting an award, students agree to comply with the following terms and conditions unless exceptions are indicated in their award offer letter:

- Students are required to work a maximum of 20 hours per week throughout the period of their award except on legal and NJIT holidays. Students are therefore required to work during semester breaks, either for their supervisor or, with the consent of the supervisor, on their own research.
- Students not receiving the maximum award for their award category and degree status are required to work a pro-rated number of hours (less than 20) based on a comparison of their award to the maximum stipend level allowed for that award. A maximum of 40 hours per week, with appropriate increase in support level, may be permitted for service during the two summer award periods.
- Full-time registration in one of NJIT's graduate degree programs must be maintained at all times throughout the period of an award. Full-time status is accorded to those who complete at least 12 credits per semester, or to those who are certified by the Office of Graduate Studies or designee as full-time students. Students should review the sections "Refunds for Withdrawal" and "Enrollment Status" to be assured that they are following full-time certification requirements.
- Students who initially register for a full-time load but withdraw during a semester and thus become part-time cannot receive tuition remission for that semester and may have their tuition award terminated and stipend award curtailed.

• No other work for compensation, whether on- or off-campus, may be undertaken during the period of the award. Students who do not comply with this requirement may be prohibited from receiving future support and will have their current award terminated.
• Unsatisfactory performance, inadequate academic progress, or violation of any of these terms and conditions shall constitute grounds for the immediate cancellation of an award.
• Award offers must be accepted in writing, on an appropriate form, and must be received by the date indicated in the award offer.
• Students who resign, or are dismissed from an appointment during a semester, must repay any tuition remitted for that semester.
• Students must report to their supervisor by no later than the first day of each semester. Students who fail to do so will be deemed to have resigned and will have their award cancelled.
• Appointments are made for the period specified in the award offer; neither renewal nor summer support can be guaranteed.
• Support based on external grant, contract, scholarship or fellowship awards are subject to the limitations established by the external agency.
• Students may not receive an award from NJIT funds to pursue a second master's degree, second engineer degree, or second doctoral degree when the first degree has been earned at NJIT.
• Students who change to a master's degree program from a doctoral program will have the current award cancelled and no future awards will be permitted.
• All doctoral students and students on support are required each semester to attend the seminar course offered by their program unless a specific waiver for sound academic reasons has been granted by the Dean of Graduate Studies. Waivers for doctoral students to allow off-campus employment through Pre-completion Practical Training Authorization or to accept a cooperative education work assignment will generally not be approved.

Tuition Remission Awards

Tuition support has no service condition associated with it. Students accepting this support must not leave the program for which the support is offered without the approval of the support sponsor and the Dean of Graduate Studies. Approval will be granted only for sound academic or other compelling reasons. Departure to accept employment is not considered a valid reason. All tuition support provided will be rebilled to the student if this condition is violated. Students receiving a tuition or fee award are required to sign a Tuition and Fee Repayment Agreement as a condition of the award. The agreement terms are implemented if students violate the conditions of the tuition or fee award.

Cancellation of Tuition Remission

NJIT reserves the right to cancel tuition remission awards when students do not meet requirements or violate the conditions of an award. NJIT also reserves the right to cancel tuition remission for ineligible courses or courses for which the grades of F, U, O, W, or I are received. Audited courses, courses outside the approved courses for the program, and excess courses not needed for program completion are ineligible for tuition remission. If tuition remission is cancelled, students are rebilled accordingly and are responsible for payment in full.

Sick Leave

Students receiving awards are entitled to a total of three paid days of sick leave during the academic year. Additional days of sick leave may result in the cancellation of an award or a reduction in a stipend.

Unsatisfactory Performance

A student's performance is considered unsatisfactory if it does not meet the criteria set by the award supervisor.

Criteria for Maintaining Award

Students must earn at least a 3.0 grade point average each semester, as well as attain a cumulative GPA of 3.0 to keep receiving their awards. A 3.0 grade point average will also maintain awards that initially required higher GPAs to receive them. Any graduate or undergraduate course taken by a graduate student is counted in the grade point average for evaluating maintenance of awards and even includes courses that were repeated or excluded. Except for the specified period of the award offer, these criteria neither guarantee nor entitle students to receive continued financial support.

Effect of Incomplete Grades and Grade Changes

Students whose transcripts show incomplete (I) grades in the semester before being selected or becoming eligible for an award must resolve them within the four weeks after grades are posted. This also applies to changes in grades that would affect eligibility.

Extension of the deadline to the fourth week of the subsequent semester will be considered if written justification is provided by the student and the instructor. Otherwise, any award offer for that semester will be withdrawn and tuition remission cancelled. Students will be billed for tuition accordingly and will be responsible for payment in full.

Award Duration and Renewal

Student eligibility for awards is evaluated each semester as is renewal of award offers. Each award has unique eligibility, funding, duration and renewal circumstances. Students are responsible for understanding and following the terms and conditions of the particular award offer made to them. The Office of Graduate Studies should be consulted to determine individual terms and conditions. Award duration is based on calendar time, not on whether awards are full or partial.
• Students enrolled in Master of Science programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than one academic year except in the cases listed below for BS/MS students and University Scholars, and U.S. nationals and permanent residents who are members of underrepresented groups. The academic year is defined as two semesters and one summer. The summer includes two award periods.
• Students enrolled in doctoral degree programs may not receive NJIT-funded, full or partial, assistantship or fellowship support for more than four academic years. This is defined as eight semesters and four summers.
• Master's students are eligible to receive awards for a maximum of four semesters and two summers from all sources. This does not apply to students in the M.Arch. program. Doctoral students are eligible to receive awards for a maximum of ten semesters and five summers from all sources.
• Students enrolled in the 97-credit Master of Architecture program may not receive NJIT-funded, full or partial assistantship or fellowship support for more than three academic years. Three academic years are defined as six semesters and three summers.
• Students enrolled in the Master in Infrastructure Planning program are considered as Master of Science students for award duration.
• Full-time master's students in the BS/MS or University Scholars program are eligible to receive three semesters and one summer of financial support from internal funds.
• U.S. nationals and permanent residents enrolled in Master of Science programs who are members of underrepresented groups are eligible for three semesters and one summer of financial support from internal funds.
• Doctoral students who fail their qualifying examinations may not receive further awards from NJIT funds until they pass. Departments may request a review and continuation of their financial support status if they pass some but not all parts of qualifying examinations.
• No student may receive support for more than twelve semesters and six summers from any combination of sources or for any number of degrees.
• When eligibility for NJIT-funded awards is completed, students may receive additional support from external sources. Check with the Office of Graduate Studies to obtain further details.

Resignations

Students who wish to resign from an award should inform their advisor and the Dean of Graduate Studies at least one calendar month before the resignation is to take effect.

Students who resign during a semester will not be eligible for tuition remission for that semester. The semester in which the resignation is received is counted as a supported semester when determining award renewals.

Taxation of Stipends and Awards

The Internal Revenue Service requires that stipends and awards be taxed at the source, even if students are eligible for a tax refund. All students are exempt from Social Security taxes. Tuition and fee remission are not subject to tax withholding.

Students should contact the Finance Office and the Office of Graduate Studies for tax information and applications for exemption from Social Security taxes. International students should contact the Finance Office and the Office of International Students and Faculty for information on tax treaties.

TUITION REMISSION

Tuition Remission Processing

All students receive bills for tuition. The bill statements for students receiving tuition remission and fees, if applicable, are marked "Possible Tuition Remission." After expiration of the official withdrawal period, a credit for the tuition and fees should appear on the statement.

Students who pay tuition bills in full and then receive tuition remission can expect to receive a refund after expiration of the withdrawal period. Students receiving only partial tuition and fee awards are responsible for payment of the remaining tuition and fees and should pay these promptly. In particular, full-time students should ensure that they have continuous health insurance coverage.

Credit Limitation

Awards do not cover tuition for courses that are not part of a student's degree program or courses not approved by their advisor. Students are responsible for payment for these courses. Students in programs that require more than 30 credits may be permitted to take more than 12 credits in a semester and receive tuition remission.

Tuition remission is allowed for courses taken at other institutions in which there is a cross-registration agreement with NJIT. These courses must be part of the student's degree program and approved by his/her advisor.

Full-time students who take 12 to 19 credits per semester pay an inclusive tuition block rate. Any credits that students take beyond 19 credits are not included in tuition remission awards. Students will be billed for these credits.

Academic Policies and Procedures

Registration

Registration is required each semester. The Registrar's office is located in Room 312 of the Hazell Center. In early 1997, the office will be re-located to the student mall, on the ground floor of the parking facility. It is open when classes are in session, Monday through Thursday, from 8:30 a.m. to 6 p.m. and Fridays, 8:30 a.m. to 4:30 p.m. Registration procedures for each category of student are listed below.

Registration also is conducted off-campus at Extension sites and via electronics.

NJIT has an advance self-registration system that obligates all students currently enrolled in graduate degree programs to register in advance for their courses. An approved registration guarantees class seats until the first class meeting. Students who do not attend the first class meeting may lose their place in class.

Approval of Course of Study

NJIT degree programs are purposely flexible to meet a variety of career and personal objectives within minimum requirements. Students are required to arrange a conference with their graduate advisor as soon as possible after notification of admission (international students should do so immediately after arrival in the United States) to formulate a course of study that meets the requirements of the particular degree program and reflects the interests and aspirations of the individual student. New students are required to obtain advisor approval for initial course registration.

Continuous Registration Requirement

Once admitted to a degree program, students must be continuously registered each semester until they complete degree requirements.

Students are not permitted to register for MR (Maintaining Registration) if their project, thesis or dissertation is unfinished without approval for a Leave of Absence by the Dean of Graduate Studies.

Students who complete work for projects, theses or disserations over several semesters receive a grade in the semester in which the work is completed and the final document is approved.

Responsibility for Registration

NJIT mails registration information in advance, but cannot guarantee postal delivery. Regardless, students are expected to obtain all necessary information and comply with all registration procedures on time. International students and students who receive financial support, must be in attendance at NJIT and will not be permitted to have other persons register for them.

Currently Enrolled Students Currently enrolled students are informed of registration procedures for the fall and spring semesters by the Office of the Registrar during April and October respectively, and must then register during the advance registration period. Students who fail to comply with these instructions are charged a late fee and must attend in-person registration. Instructions for the summer session are provided separately. Currently enrolled extension, distance learning, and graduate certificate students are informed of registration procedures for fall, spring and summer semesters by the Division of Continuing Professional Education.

New and Readmitted Students Prospective students are informed of registration procedures by the Office of University Admissions.

Non-Matriculated Students Non-matriculated students should contact the Office of University Admissions for details of admission and registration procedures at least one month before the date of intended enrollment. Extension, distance learning and graduate certificate students should contact the Division of Continuing Professional Education.

Course Additions

Courses may be added up to and including the first week of a semester. Full tuition and fees will be charged. A schedule change fee is assessed if the change is made during the first week of the semester.

Course Cancellations

The university does not guarantee offering all or any of the courses listed in this catalog. When there is inadequate registration for a course, it may be cancelled without notice. The Registrar will attempt to notify all students of course cancellations before the first meeting of the semester.

Multiple Registration

A student cannot be matriculated in more than one graduate degree program at a time. This also applies to programs run cooperatively with the Newark Campus of Rutgers University and the University of Medicine and Dentistry of New Jersey. Currently enrolled graduate students who wish to enroll in a subsequent graduate degree program should *NOT* file an application for admission to the new program until they are in the final semester of their initial program. In addition, students may not be enrolled in both a degree and a non-degree graduate program, or as an undergraduate and graduate student simultaneously.

Students should consult the Office of University Admissions when contemplating a change in program enrollment. Students should refer to "Change of Major" under "Admissions" in this catalog.

Cross-Registration Procedures

Students may take courses at The University of Medicine and Dentistry of New Jersey and Rutgers-Newark College of Arts and Sciences provided that the:

- Course is used toward a degree.
- Course is not offered at NJIT, or, because of a conflict in schedule, cannot be taken at NJIT.
- Approval is obtained, in advance, from the student's advisor.
- Approved cross-registration form is submitted by the student to the host school. The course must also be included on the NJIT registration form.

Students in joint programs should register at the school that admitted them to their current degree program. Students from Rutgers-Newark and UMDNJ must be matriculated in graduate programs at their home institution to cross-register for NJIT courses.

Registration at Another College

To take graduate courses at colleges other than those in the cross-registration program, students must obtain prior approval from their advisor and the Dean of Graduate Studies. Students should review the section on "Transfer of Credit" if they wish to transfer these courses to an NJIT program.

Tuition remission from NJIT is not available for courses taken at educational institutions not participating in NJIT's cross-registration program.

Graduate Registration in Undergraduate Courses

Graduate students may be asked to register in undergraduate courses as conditions of admission as bridge courses or by direction of the graduate advisor for their current program. Enrollment in other undergraduate courses requires the approval of the Dean of Graduate Studies or the graduate advisor, and the undergraduate department offering the course. Tuition for these courses is assessed at the graduate rate.

Undergraduate Registration in Graduate Courses

Undergraduate students who wish to take 500- or 600-level courses must obtain the written approval of the graduate advisor for the program which offers the course and their undergraduate advisor. If undergraduates wish to take 600-level courses, they must also obtain written approval from the chairperson of the department offering the course. Undergraduates are not permitted to take 700-level courses.

Undergraduate students who enroll in graduate courses for undergraduate credit pay tuition at the undergraduate rate. Grades will follow the graduate grading system.

The student's academic record will be reviewed by the undergraduate and academic advisor prior to approval. Approval can be granted only to students who have completed the appropriate prerequisites for the course and are in satisfactory academic standing. The approval will be noted on a form that requires appropriate signatures and reports the student's cumulative undergraduate grade point average. Students shall have a cumulative undergraduate grade point average of 2.5 to be approved for registration in 500-level courses (500G for Architecture) and 2.8 for registration in 600-level courses.

Students whose undergraduate grade point average is below the 2.5 or 2.8 minima, are considering courses out of the student's current major, are lacking appropriate prerequisites, have completed any prior graduate courses with a grade below a B, or have already completed 9 or more credits at the 500 level and above (15 credits for those in the BS/MS program), or have an excessive number of credits for the undergraduate degree will also require review by the Dean of Graduate Studies and the program advisors.

Undergraduate students should be aware that need-based financial aid may not be sustainable for registration in graduate courses.

Identification Card

All students must carry an NJIT identification card while on campus. An ID must be presented at the request of a university administrator, faculty member or public safety officer. Facilities, parking, building access, and services of the university require presentation of a valid university ID.

Students should obtain an ID card as soon as possible after registration is completed. Photographs for ID cards are taken throughout the semester in the Office of Public Safety, located in the parking facility. Dates and times to obtain an ID are posted at the Hazell Center Information Desk. Proof of registration in the form of a tuition receipt or registrar's receipt is required to obtain an ID card. These receipts also will be accepted as NJIT identification until the ID card is issued. ID validation stickers are issued each semester during registration periods and are available at the Office of Public Safety or the Hazell Center Information Desk.

Lost or stolen IDs should be reported as soon as possible to the Office of Security, also located in the parking facility. A replacement for a lost card is obtained by paying a $25 charge at the Bursar's Office cashier window and presenting the receipt at the Office of Public Safety where the card will be re-issued.

Transfer of Credits from Outside NJIT

Transfer credits are calculated by NJIT according to the total number of instructional minutes earned at the other institution. The equivalent instructional minutes of a maximum of 9 credits of graduate work, taken within seven years, from accredited U.S. educational institutions may be transferred and applied to degree requirements at NJIT. *Credits from educational institutions outside the United States cannot be transferred.* On a case by case basis, up to 9 credits may be waived for non-collegiate based instruction. The university does not grant transfer credit for work experience or other non-instructional activities.

Credits are transferred only if the courses were taken for full academic credit, were never applied to any other degree, and a final grade of at least B was attained. In addition, the student's graduate advisor and the Office of Graduate Studies must agree that such courses directly relate to the student's program of study before they can be transferred.

Requests for transfer credit must be submitted on a form available from the Office of Graduate Studies, accompanied by course descriptions from the other educational institution. Students must also arrange for the other institution to send an official transcript to the Office of Graduate Studies at NJIT. Requests may be submitted and approved at any time but are not added to a student's record until matriculation is granted. Grades that are transferred will not be calculated in cumulative grade point averages.

Transfer of Credits within NJIT

There are many circumstances under which credits earned at NJIT, while a student is in one program, may be shifted to a new program.

BS/MS and University Scholars Programs

Under the BS/MS and University Scholars program, 6 credits may be counted toward both an undergraduate and a graduate degree at NJIT. These credits are shifted to the graduate record with the approval of the BS/MS and University Scholars program advisor and the direction of the Office of Graduate Studies after completion of the undergraduate degree and continuation in the graduate program. There is no additional billing for this transfer.

Graduate credits taken by undergraduates that are not required or counted toward the undergraduate degree regardless of participation in the BS/MS or University Scholars program may be shifted to the graduate record with the approval of the graduate advisor and the Office of Graduate Studies. These courses are subject to billing at the difference between undergraduate and graduate per-credit tuition rates at the time of the transfer.

MS/MS and Joint Master's Programs

The MS/MS program allows students to pursue a second NJIT Master of Science degree on completion of the first and to count two courses (6 credits) from the first degree toward the second. The option must be exercised within two years of completion of the first degree. The approval of the advisors of the two programs is required. The Office of Graduate Studies will direct the Registrar on transfer of the two dual-use courses to the second program. Thesis, project, predoctoral research, independent research, and similar courses may not be used. Several other master's degree combinations involving the Master of Architecture that allow dual use of courses from the first degree to the second are pending approval. The MS/MS program option is not intended for students who have left the Ph.D. or Degree of Engineer programs without completion of the degree. Up to 6 credits may be transferred to the second master's degree from outside NJIT.

Scheduling of Classes

Graduate courses at NJIT and at Extension Sites are, in general, scheduled for late afternoon and evening hours and Saturdays for the convenience of those employed full-time. Evening courses normally begin at 6 p.m. and end at 9:00 p.m. Some laboratory sessions begin at 6 p.m. and end at 9:50 p.m.

Courses in heavy demand may be scheduled for additional sections if adequate enrollment can be assured. Day and evening classes during the summer months are possible under the same conditions. Special programs such as the Executive Management program and those offered by Distance Learning have their own schedules.

Room Changes

Room and laboratory changes are announced on the bulletin boards outside the Office of the Registrar. Changes are posted adjacent to doors of originally scheduled rooms, as well.

Enrollment Status

Full-Time Students Students registered for 12 credits or more throughout an entire semester are considered full-time.

International students and students receiving financial awards must have full-time status each semester.

Part-Time Students Students registered for fewer than 12 credits during a semester, unless certified as full-time by the Office of Graduate Studies.

Half-Time Students For federal and other reporting purposes, half-time graduate student status is given to students registered for 6 credits or fewer during a semester. Contact the Office of Graduate Studies for more information.

Full-time Certification Graduate students must be registered for not less than 12 credits each semester in order to be accorded full-time status.

The Office of Graduate Studies may certify students as full-time even if they are not registered for 12 credits, provided that:

- Students have fewer than 12 credits remaining for completion of all degree requirements and are registered for all credits needed to complete the degree. This certification can only be given for one semester.
- Doctoral students preparing for qualifying examinations or research proposal presentations register for at least 9 credits.
- Doctoral candidates have completed all course work, other degree and credit requirements, and are registered in Dissertation Research and seminar for at least 3 credits each semester.
- Students originally registered for 12 credits but have substantial extenuating circumstances that require a reduction in course load. Normally this certification applies only in cases of medical or similar emergencies which incapacitate a student for a significant part of a semester. Improper course registration, failure to seek proper advisement, inadequate academic progress, or risk of earning a weak or failing grade are not extenuating circumstances.
- Students on a full-time cooperative education assignment are registered in the Co-op Work Experience or equivalent course. When students are in their final semester of study, they may be certified as full-time and approved for co-op. The Office of Graduate Studies should be consulted for limits on cooperative education as it has an impact on full-time certification and allowable time to complete the degree.
- Audited courses and withdrawn courses do not count toward full-time status; ESL (English as a Second Lanaguage) courses do count as one course.

Graduate Degree Requirements

Graduate degree candidates must achieve a cumulative grade point average of at least 3.0 in all graduate-level courses and satisfy other academic and non-academic requirements. These include financial obligations to the university. Until the Office of Graduate Studies verifies that all tuition bills and fees have been paid, and that the master's thesis or doctoral dissertation and abstracts have been completed in the appropriate format, degrees will not be certified. Students whose programs require a thesis, project or dissertation, must complete these within time limits, format, and policy prescribed by the Office of Graduate Studies. Master's Theses, Degree of Engineer Projects and Doctoral Dissertations must be submitted for final approval to the Office of Graduate Studies. Master's Projects need to be submitted only to the advisor or program office. At least three program approval signatures are required for Master's Theses and Degree of Engineer Projects; at least five are required for Doctoral Dissertations. Fees that must be paid include, but are not limited to, the binding fee, full publishing fee, copyright fee, and graduation fee.

GRADE POINT AVERAGE CALCULATION

In order to obtain a graduate degree, candidates must have a cumulative grade point average of at least 3.0 in all graduate-level courses, exclusive of grades in Master's Project, Master's Thesis, or Doctoral Dissertation. All 500-level or higher courses are included in the cumulative grade point average, regardless of applicability to a specific degree. Only the initial grades for graduate courses that have been repeated are excluded from GPA calculations.

In addition, the cumulative grade point average for all courses counted for the degree, exclusive of Master's Project, Master's Thesis or Doctoral Dissertation, must be 3.0 or better. Grades for Master's Project or Thesis must be a B or better. The Doctor of Philosophy degree is discussed under "Doctor of Philosophy" in this catalog. Some programs also may require a 3.0 GPA in designated core course requirements.

Expiration of Credit

For all degrees, credits expire seven years after completion of the semester in which they are earned. Expired courses cannot be used to fulfill degree requirements and must be replaced by current credits.

Degree requirements must be completed within seven consecutive years of original admission. Approved Leaves of Absence do not count against the seven-year limit for completion of the degree although the validity of individual courses may still expire during this time. Requests for waivers of the seven-year limit for extenuating circumstances, other than mere failure to register, are made to the Dean of Graduate Studies. The technical content and remaining currency of courses is considered in evaluating these requests. The majority of courses in rapidly changing fields (such as computer science) are not likely to be accepted after seven years.

AWARDING OF DEGREES

Degrees are awarded three times each academic year: October, January and May. Diplomas are dated Oct. 1 for October graduates and the date of the January or May commencement for January and May graduates, respectively. Candidates for graduation must file an Application for Candidacy with the Registrar. Applications received after the specified deadline are accepted at the discretion of the Registrar and are subject to a late fee. Forms are available from the Registrar. Unsuccessful applications will be automatically added to the next commencement list and students will be billed for the appropriate fees.

■ MASTER OF ARTS

See Master of Arts in History and Master of Arts in Teaching (History) on page 62.

■ MASTER OF SCIENCE

Master of Science degrees require a minimum of 30 credits: 18 credits in an area of specialization that may include a 6-credit thesis or 3-credit project, and 12 credits of electives. Some programs may require students to take more than 30 credits to fulfill degree requirements. The necessity and requirements for a Master's Project or Thesis and defense are established by the particular programs and departments.

The 18 credits in an area of specialization must be courses numbered 600 or above, depending on program requirements. With the written approval of the department of major study, 6 of these credits may be in courses numbered 500 to 599.

The 12 credits of electives are subject to advisor approval. Typically, students are permitted to take at least 6 elective credits outside the department of major study.

More detailed descriptions of requirements may be found in the Degree Programs section of this catalog.

Bridge Program: Students who seek graduate degrees in an academic discipline different from the discipline in which they received their baccalaureate degree may be required to take additional courses. The program of courses will be individually designed in consultation with their graduate advisor. Such courses must be taken before beginning graduate curricula. They may include undergraduate courses. These courses are not counted toward degree requirements but if they are numbered 500 (500 G for architecture) or higher, they are calculated in cumulative grade point averages.

■ MASTER'S DEGREES IN ARCHITECTURE

A full description of these requirements may be found in the Degree Programs section of this catalog.

■ DOCTOR OF PHILOSOPHY

The number of credits required for completion of doctor of philosophy degrees varies with the program and the level of entry into the program. Students holding a prior master's degree will require a minimum of 60 graduate credits beyond the master's degree (which is assumed to have included at least 30 graduate credits beyond the bachelor's degree). Students entering the doctoral program with a bachelor's degree and who do not wish to complete a master's degree while pursuing the doctoral degree will be required to complete a minimum of 84 graduate credits beyond the bachelor's degree for programs offered by the Newark College of Engineering and 78 graduate credits beyond the bachelor's degree for programs offered by the College cf Science and Liberal Arts. Doctoral program credit requirements for programs offered by Rutgers-Newark with NJIT collaboration are defined by Rutgers-Newark. Doctoral program credit requirements for joint programs, with both university names to appear on the diploma, are to follow the requirements of the program as

approved by the two universities, generally a minimum of 72 credits beyond the bachelor's degree.

In addition to overall credit requirements, each program includes the following minimal requirements:

- For those entering the program with master's degrees, 24 credits of course work beyond the master's degree of which at least 12 credits must be at the 700 level and none at the 500 level.
- For both entry levels, at least 12 credits of course work at the 700 level; no more than two Independent Study courses may be used to satisfy this requirement. Master's Project or Thesis cannot be used to satisfy this requirement.
- 36 credits of doctoral dissertation research for programs offered by Newark College of Engineering.
- 30 credits of doctoral dissertation research for the program in computer science.
- Dissertation research credits in accordance with the program approval documents for programs offered by the College of Science and Liberal Arts, jointly with Rutgers-Newark, or by Rutgers-Newark directly. In no case will this be fewer than 36 credits for NJIT programs.
- Seminar attendance each semester. Nominal credit values, if any, for registration in seminar do not count toward fulfillment of overall credit requirements.

Students who wish to complete a master's degree while pursuing a doctorate, must apply for admission to the master's program, and satisfy all requirements for the master's degree, including any thesis or project requirement. As also discussed under "Terms and Conditions of Awards" in this catalog, students in doctoral programs initially, who terminate their studies at the master's level, will lose further eligibility for support.

Qualifying Examination

Students must pass a qualifying examination within two years of being admitted into doctoral programs. Exceptional students only having bachelor's degrees who are admitted into doctoral programs must take the qualifying examination within one and one-half years of admission and must pass it within two years. Students are only permitted to take the examination twice. The passage of qualifying examinations is reported to the Office of Graduate Studies. Each department determines its own policies with regard to format, confidentiality, grading, and review of examinations by faculty and students.

Doctoral Candidacy

Students become doctoral candidates when they pass the qualifying examination. Status as a doctoral candidate does not imply candidacy for the degree. Registration for doctoral research is permitted only to doctoral candidates. Doctoral students who are not yet doctoral candidates may register for pre-doctoral research, subject to program policy.

Dissertation Committee

A dissertation committee is formed in the six months after passing the qualifying examination. Department chairpersons or doctoral program directors are responsible for approving formation of dissertation committees. Most dissertation committee members are faculty from the students program or department. The dissertation committee chairperson typically is the doctoral candidate's program advisor, but other faculty may be selected, provided that they are from the student's program or department. The committee consists of a minimum of five members, one of whom is external to the program, or to NJIT. For candidates whose program is interdisciplinary and in more than one department, the external member must not be connected to the student's program or discipline.

Research Proposal

Doctoral candidates must prepare a research proposal for approval by their dissertation committee. Each program has specific requirements for preparing, presenting, and accepting proposals. Research is expected to investigate or develop a unique contribution to science and technology. Research may be experimental, analytical, applied, or theoretical, provided it satisfies this criteria and is approved by the dissertation committee.

Residency

Doctoral candidates must spend at least one academic year in full-time residence. This requirement is sometimes waived with the approval of the dissertation committee and the Office of Graduate Studies. Such waivers are granted when a candidate's dissertation research requires use of research facilities at an approved off-campus site.

Dissertation and Defense

A dissertation should result in scholarly publication and must be defended in a publicly-announced oral defense. Successful defense of the dissertation is determined by vote of the dissertation committee. All members of the committee must be present to hear the defense.

Each program has its own policies on scheduling and submitting dissertation drafts to members of the dissertation committee. Students are responsible for following their program's dissertation policies. In regard to format, the standard reference is the latest edition of the Estrin/Roche manual: *Guidelines for Scientific and Professional Theses.* Office of Graduate Studies policies on number of copies, deadlines, and submission of dissertation and abstracts are also to be followed.

Every member of the dissertation committee must sign the approval page of the final dissertation document.

GRADE POINT AVERAGE

In order to obtain the Doctor of Philosophy degree, candidates must achieve a cumulative grade point average of at least 3.0 in all graduate courses. The 3.0 minimum does not include the grade assigned for completion of the doctoral dissertation. Completion of the dissertation and its defense will be assigned a grade of P for "Passing." The P grade is for dissertation credits taken in the student's final semester.

■ DEGREE OF ENGINEER

The Degree of Engineer requires a minimum of 36 credits: 24 credits of courses beyond the master's degree, of which at least 12 must be at the 700 level, none at the 500 level; and 12 credits of a professional project.

Upon completion of 12 credits of course work, candidates for the Degree of Engineer must pass a written examination. Once students pass the examination, they are assigned to a candidacy committee that assists them in planning a program of further study that reflects the candidate's academic and professional background and proposed Professional Project.

The Professional Project should involve advanced technology. A report of the project must be defended at an oral examination. The examining committee will include faculty from related disciplines, as well as practicing engineers in the field of the project.

Grade point requirements for the Degree of Engineer are similar to those for master's degrees. The Professional Project must be completed in a format similar to a Master's Thesis.

■ GRADUATE CERTIFICATE REQUIREMENTS

Certificates require completion of 12 specified credits with a GPA of 3.0 or better. Graduate certificate credits may be applied to a following master's degree. Dual use of credits from a completed first master's degree to a second and following certificate is not permitted.

Academic Standing

GRADES

The Registrar issues a grade report to each student at the end of each semester. Grade point averages are calculated for each semester and cumulatively for the entire graduate record. Undergraduate credits taken by graduate students are not counted. The following grades are used:

Grade	GPA	
A	4.0	Excellent
B+	3.5	Good
B	3.0	Acceptable
C+	2.5	Fair
C	2.0	Minimum Performance
F	0.0	Failure
I		Incomplete
W		Approved Withdrawal
AUD		Audited (No academic credit)
S or U		Satisfactory or Unsatisfactory
P		Passing for Doctoral Dissertation and Defense

Incomplete Grades

A grade of I (Incomplete) is given when courses cannot be completed because of special circumstances. Students on academic probation are not permitted incompletes without permission from the Office of Graduate Studies. Required course work may be finished at the discretion of the instructor, no later than the end of the subsequent semester. A letter grade must be assigned or a grade of "F" will be given. Students nominated for financial awards must have I grades resolved by the fourth week of the subsequent semester to allow a determination of their eligibility for the award. This grade cannot be changed. A grade of "I" cannot be given for thesis, project, dissertation, seminar, pre-doctoral research courses, or ESL courses.

Course Withdrawals

Withdrawal from graduate courses, without academic penalty, is permitted until the end of the ninth week of the semester. A notation of W on the student's transcript signifies an approved withdrawal. Withdrawal forms may be obtained from the Office of the Registrar. Approved withdrawal takes effect when the Registrar receives the completed withdrawal form from the student within the designated nine-week period.

A failing grade will be issued to students who do not notify the Registrar of withdrawal in this manner. Students who do not obtain an approved withdrawal are obligated to pay full tuition and fees. Any refunds for approved withdrawals follow the refund schedule established by the Registrar. Withdrawals that affect conditions for retention of financial awards or support, continued full-time status, academic probation, progress toward a degree, admission, ESL, or participation in special programs must be approved by the Office of Graduate Studies.

After the ninth week of the semester, students may withdraw from a course only for extenuating circumstances with the approval of the Dean of Graduate Studies and by the graduate program advisor.

Auditing a Course

Students who wish to audit a course must state their intention to do so at the time of registration. Change in auditing status is not permitted once a semester has begun. Students who audit are required to pay full tuition and fees for the course. Financial awards are not applicable to audited courses. Audited courses are not counted in determining full-time status. Students on probation are not permitted to audit.

Satisfactory and Unsatisfactory

The grades S or U report progress in project, thesis, dissertation, and pre-doctoral research courses. These also can be final grades in seminar, Co-op, teaching methods, and ESL courses. The grade of S is given for satisfactory progress and U is given for unsatisfactory progress. Students who fail to meet with their advisors will receive a U grade. Credits for courses in which U is received cannot count toward a degree.

Theses and Dissertations

Theses and dissertations submitted for graduate degrees must follow a prescribed format. A manual outlining the university requirements for thesis and dissertation submission is available in NJIT's bookstore. The Office of Graduate Studies should be consulted for more information.

Final Grades in Project, Thesis, Dissertation and Research

Letter grades are given for satisfactory completion of project, thesis, or pre-doctoral research requirements. Projects and theses must be submitted first, before a grade can be given. Theses and dissertations are submitted to the Office of Graduate Studies. Projects are submitted to the project graduate advisor. Semester and cumulative GPA calculations by the Registrar only include courses for which a letter grade is given. For the purpose of the GPA, the Registrar only calculates the grades for credits earned in the semester in which the project, thesis or dissertation is completed. Letter grades cannot be given for an unfinished project, thesis, dissertation, or pre-doctoral research nor for work not submitted. A grade of P is given for satisfactory completion of a doctoral dissertation and defense. Receipt of two U grades for project, thesis, dissertation, or pre-doctoral research will result in a letter grade of F in place of the second U and dismissal from the program.

Grade Changes

Grade change requests will not be accepted after the end of the subsequent semester.

Grade Disputes

Students are expected to resolve disputes about grades with their instructors. If they cannot reach a satisfactory settlement with their instructor, students are permitted to request the intervention of the chairperson of the department and the Dean of the school or college. The Dean of Graduate Studies may be consulted.

In all cases, final authority to award grades rests with the instructor.

Transcript of Grades

Students who wish to have a transcript issued on their behalf must submit a request in writing to the Registrar. (Only unofficial copies will be supplied directly to either current or former students.) Transcript requests must be accompanied by a $3 fee for each copy. Transcripts will not be issued to, or on behalf of, former students who still owe money to NJIT. Requests for transcripts are processed in five to ten working days.

Independent Study

Some programs permit up to three independent study courses (a total of 9 credits) towards degree requirements. Independent study is for students who want highly specialized study in areas in which courses are not normally available. Students should see their advisors regarding independent study options. For students in doctoral programs, a maximum of two independent study courses may be used to satisfy the 700-level course requirements.

Course Repetition

Graduate students may request approval to repeat a course using a form available from the Office of Graduate Studies. The grade received in a repeated course is calculated in the cumulative grade point average, but the first grade still appears on the transcript. A maximum of two courses may be repeated in graduate studies. Students may not repeat a course without prior approval from the department and the Office of Graduate Studies. Students who receive an F in a course will be required to repeat that course. The Dean of Graduate Studies should be consulted if the course is no longer offered or not applicable to the student's current program.

PROGRESS TOWARD DEGREE

Academic Performance and Satisfactory Progress Policy

New Jersey Institute of Technology requires that students maintain satisfactory progress in working toward a degree. Federal and state regulations governing financial aid and awards require that students receiving aid from government agencies must meet academic performance and progress requirements defined by the university and approved by the appropriate government agencies. Students are responsible for checking regularly with the office or the department of major study or the Office of Graduate Studies to determine if they are fulfilling degree requirements.

The Office of Graduate Studies, along with academic departments, reviews academic standing of all graduate students at the end of each semester. To have satisfactory academic standing students must have a cumulative GPA of 3.0 or above, meet all university requirements and satisfactorily progress toward a degree. Students who do not have satisfactory academic standing are subject to academic warning, academic probation, and academic dismissal.

ACADEMIC WARNING

Students who have completed one semester, or less than 15 credits, and do not have satisfactory academic standing may be asked by the Office of Graduate Studies to visit in-person to review their academic record and also meet with their graduate advisor. This is not noted on the permanent academic record.

ACADEMIC PROBATION

Students who have completed two or more semesters, or more than 12 credits, and do not achieve satisfactory academic standing may be placed on academic probation or subject to dismissal. Conditions for continuing graduate studies at NJIT are sent, in writing, to students on academic probation. The Office of Graduate Studies will work with students to determine approaches toward successful program completion. Course repetition or the taking of up to 6 additional credits are typical of recommendations for students whose GPA is below 3.0 and have the ability to raise the GPA to 3.0 with appropriate grades.

Students on academic probation may not maintain registration without the approval of the Office of Graduate Studies. Academic probation is noted on the permanent academic record.

DISMISSAL

Students may be dismissed from Graduate Studies for cause at any time. Cause shall include, but is not limited to:

- Failing to meet the conditions of admission.
- Failing to maintain a cumulative GPA of at least 3.0 after completing one semester or attempting at least 12 credits.
- Failing to make satisfactory progress toward a degree.
- Failing to meet the requirements for graduation.
- Failing a required or repeated course more than once.
- Failing to satisfy requirements for project, thesis, or dissertation within the required time limits.
- Failing doctoral, qualifying, and similar examinations required for continuing studies in the program, or failing to take examinations within prescribed time limits.
- Professional conduct offenses as defined in the *Student Handbook.*
- Making a false representation relating to admission, registration, or the awarding of financial support.
- Failure to pay all tuition, fees, and other charges within the required time limits.

Dismissal is noted on the permanent academic record.

Appeals

Decisions relating to a graduate student's academic status are made in accordance with regulations approved by the faculty and its standing committees. Committees include, but are not limited to, the Graduate Council and the Committee on Academic Affairs.

Students who disagree with a decision should resolve the matter with those immediately responsible. When a matter cannot be resolved at this level, students should appeal to the chairperson of the department and then to the dean of the college. At any time, the student may request that the Dean of Graduate Studies be consulted.

A graduate student who remains dissatisfied may appeal the decision to the Committee on Graduate Appeals through the Office of Graduate Studies. The committee's decision, made in writing, is final. Student requests for review or appeal must be in writing and state accurately and completely the decision being appealed, when it was made, by whom, and the reason for the request. Requests should be sent to the Dean of Graduate Studies. A copy of the request together with transcripts, test scores, and other information that form the student's record are distributed to the committee members for their consideration.

Readmission if Dismissed

Students dismissed from NJIT may apply for readmission to another degree program after at least one calendar year.

Students dismissed for professional conduct offenses or for making false representation will not be readmitted to NJIT.

Other dismissed students who seek readmission after dismissal should apply to the Office of University Admissions at least two months before the date of intended readmission. These students must complete, in full, the application for admission and provide all requested documentation, regardless of previous applications. Readmission is treated as a new application. Readmits compete against all other applicants for admission that semester. The circumstances and conditions of the dismissal will be considered in the readmission process.

Students who reapply should also include supportive material to justify readmission. Such material may include, but not be limited to, scores obtained in the Graduate Record Examination or Graduate Management Admission Test, grades obtained in graduate level work at other institutions, letters of recommendation, and statement by the applicant. Applications must be accompanied by a non-refundable fee of $35.

Discontinuance

Students enrolled in graduate programs who find it necessary to temporarily discontinue their studies may either maintain registration, request a Leave of Absence, or voluntarily discontinue. A discontinuance form must be filed with the Office of Graduate Studies. International students may not discontinue studies, but may seek approval for a Leave of Absence at which time MR may be authorized. Students who are discontinued must follow procedures defined by the offices of University Admissions and Graduate Studies.

MAINTENANCE OF REGISTRATION

Students enrolled in a degree program who find it necessary to temporarily discontinue their studies are permitted to maintain registration for a fee of $50 for each semester they do not register. International students are not permitted to maintain registration but they may seek approval for a Leave of Absence from the Office of Graduate Studies.

Students who maintain registration are mailed registration materials for the following semester and are not required to reapply for admission. To maintain registration, students should write "MR" under the course identification heading on registration forms.

Each semester in which registration is maintained is counted in the total time period allotted to complete degree requirements except for students with an approved Leave of Absence.

LEAVE OF ABSENCE

Students who anticipate a protracted absence from the university may request a Leave of Absence from the Office of Graduate Studies. Students requesting a Leave of Absence for medical reasons will be required to consult with the Office of Health Services first. Leaves are granted for up to one year and may be extended for a second year. Leaves of Absence are not counted toward the seven-year period in which the degree must be completed, but rules regarding expiration of credit do apply for course work, projects, thesis, and dissertation research. Students returning, on-time, from an approved Leave of Absence are not required to apply for readmission but are required to inform the Office of Graduate Studies and the Office of University Admissions on their return. They also are required to consult with their graduate advisor.

Readmission

Students who have voluntarily discontinued their studies without receiving a leave of absence, and who have not been dismissed from the NJIT graduate program must apply for readmission to the Office of University Admissions by the application deadline. Applications must be accompanied by a non-refundable application fee. Applicants are subject to all probationary and unmet conditions in force at the time they discontinued their studies. Program requirements at the time of readmission will apply in addition to satisfaction of any prior unmet conditions.

Project, Thesis and Dissertation

Students may not register for project, thesis, or dissertation credits until they arrange for a department-or program-approved faculty advisor to supervise the work. Continued registration for additional thesis, project, or dissertation credits will be allowed as long as the advisor grades the work to show that there is satisfactory progress. Credits for which a U (unsatisfactory) grade is given are not counted as degree credits toward completion of the thesis, project, or dissertation.

Master's project or master's thesis registration must be at least 3 credits during a semester or summer session. Doctoral dissertation registration must be at least 6 credits during a semester, until the 36 credit requirement is reached, at which time 3 credit registrations are permitted.

All students must have their advisor's signature and section identification each time they register for project or thesis. Students must register for thesis, project, or dissertation work within the deadlines established by the Register.

Doctoral dissertation registration may be 3 credits during a summer session. Engineer project registration must be at least 6 credits per semester until the 12 credit requirement is reached, at which time 3 credit registrations are permitted. Engineer project registration may be 3 credits during a summer session.

Maximum credit registration each semester is 12 credits for the doctoral dissertation, 6 credits for the master's thesis and engineer project, and 3 credits for the master's project.

Once a student has begun master's project, master's thesis, engineer project, or doctoral dissertation, s/he must register for these courses each semester until the project, thesis, or dissertation is completed. Unapproved interruptions in project, thesis or dissertation may be subject to billing for omitted credits.

Students must be registered in project, thesis or dissertation in any semester or summer session in which completion is expected. A final grade is assigned by the advisor for thesis or dissertation when the Office of Graduate Studies confirms it has received all documents in final and approved form and all related bills have been paid.

Approval by the graduate program advisor and the Office of Graduate Studies must be obtained if the student wishes to interrupt the thesis, project, or dissertation for a semester or more. Students may neither maintain registration, nor fail to register without notifying and getting approval from the graduate program advisor and the Office of Graduate Studies. If a master's project is not completed after two semesters' registration, a final grade of F is given. Failure to complete a master's project by students who receive financial support may result in dismissal.

No more than four semesters and two summers of registration for a master's thesis are permitted. Failure to complete a master's thesis within this period will result in a final grade of F, and may result in dismissal.

No more than six years of registration for doctoral dissertation is permitted. Failure to complete a doctoral dissertation in this period will result in a final grade of F, and dismissal from the program.

No more than four years of enrollment for an engineer project will be permitted. Failure to complete an engineer project by the end of the fourth year of enrollment shall be cause for posting an F grade and dismissal from the program.

Students who require additional time to complete a project, thesis, or dissertation should appeal for an extension, in writing, to the graduate program advisor, the department, and the Office of Graduate Studies. If the appeal for an extension is denied, the student may appeal further in the following order: department chairperson, dean of the school or college, and finally to the Committee on Graduate Appeals. Appeals may be accompanied by any materials that the student believes appropriate. Appeals to the Committee on Graduate Appeals should be directed to the Dean of Graduate Studies. All decisions of the Committee on Graduate Appeals are final.

DEADLINE WAIVER

Applicants for January or May graduation whose master's thesis or doctoral dissertation is *substantially complete,* but who are unable to submit it in final form by the specified date, may request a "deadline waiver" from the Office of Graduate Studies before it is due. Students granted a waiver may be permitted until a date specified by the Office of Graduate Studies to submit the final copy of the work to them. Such students may then apply for the next scheduled graduation without having to pay for additional thesis or doctoral dissertation credits. Contact the Office of Graduate Studies for further information.

Students who do not meet the deadline waiver will be required to register for master's thesis or doctoral dissertation in the subsequent semester to obtain a final grade.

Rights and Responsibilities

Code of Professional Conduct

New Jersey Institute of Technology requires students to conduct themselves with decorum and to adhere to standards of ethical and professional behavior. NJIT has adopted, and requires all students to comply with, a code of "Professional Conduct." The policies and procedures governing this code are contained in a separate publication, the *Student Handbook,* and are deemed incorporated into this catalog. A copy of the handbook may be obtained from the Office of the Dean of Student Services.

Family Educational Rights and Privacy Act

The Federal Family Educational Rights and Privacy Act of 1974 gives students the right to inspect any educational records about them maintained by NJIT. Students have the right to a hearing to challenge the contents of these records, and also have the right to add to their records an explanation of information they challenge. Unless specifically exempted by the public law, NJIT is mandated to keep student records strictly confidential.

The university Registrar is responsible for student records. Educational records are defined as transcripts, admission files and registration forms. To review their files, students must contact the Registrar, in writing, to specify the items they want to see. Student health records are maintained by the Director of Health Services and may only be examined by a health professional chosen by the student.

Educational records defined by the public law must be made available within 45 days after a student requests to see them. A catalog of educational records kept by NJIT is available from the Registrar. Exceptions to the right of inspection include financial aid records and records of institutional, supervisory, and administrative personnel, and ancillary educational personnel.

For a nominal service fee, copies of these records may be made for students.

Only those at NJIT acting in the student's interest are allowed access to student files, including personnel in the registrar's, admissions, student services, and finance offices; and academic personnel within the limitations of their need to know.

With the exceptions stated in the law, no one outside NJIT shall have access to a particular student's educational record without the written consent of the student, except in extraordinary circumstances such as emergencies. Accrediting agencies carrying out their accrediting function and certain state and federal officials are permitted access. A record of, and reasons for, granting access will be kept by the university and will be available to the student.

The university, at its discretion, may provide directory information, in accordance with the provisions of the law including a student's name, address, telephone listing, date and place of birth, major field of study, participation in officially recognized activities and sports, weight and height of members of athletic teams, dates of attendance, degrees and awards received, and the most recent previous educational agency or institution attended by the student. Students who desire directory information to be withheld should notify the Registrar in writing within the first two weeks of initial registration.

Request for non-disclosure will be honored by the university for ONLY ONE ACADEMIC YEAR AT A TIME. Authorization to withhold directory information must be filed annually in the Office of the Registrar.

Students who disagree with an entry may challenge its accuracy with the Office of the Registrar. If this remedy fails, either NJIT or the student may request a formal appeal hearing. The law mandates that such hearings be held within 30 days of requests, and be conducted by a university official or other person with no direct interest in the outcome. Students will be given a full and fair opportunity to present relevant evidence and be represented by their own counsel.

Students may include a written statement in their file explaining a disputed entry following an unfavorable determination of an appeal. A written decision will be rendered within 15 working days after the hearing of an appeal.

Students who believe that they are treated unfairly or improperly and contrary to the provisions of the law may request, in writing,

assistance from the president of the university. Students who believe that their rights have been abridged may file complaints with the appropriate federal agency.

Anti-Discrimination Policy

New Jersey Institute of Technology reaffirms its commitment to a policy of non-discrimination on the basis of race, sex, sexual orientation, age, religion, ethnic origin, handicap or veterans' status in its employment policies, educational programs and activities under university control.

Assuring a climate of equal opportunity is the direct responsibility of all levels of management. Administrative and supervisory personnel are required to comply with applicable government regulations and the affirmative action goals of the university. Among these are Executive Orders 11246 and 11375 (Affirmative action); the Civil Rights Act of 1964, as amended; Title IX of the Education Amendments of 1972 (Sex Discrimination); Section 504 of the Rehabilitation Act of 1973; Americans with Disabilities Act (Non-discrimination on the Basis of Handicap); The New Jersey Law Against Discrimination, Title 10, Chapter 5, 10:5-1 to 10:5-28, NJ Revised Statutes, as amended; and the New Jersey Governor's Code of Fair Practices, Executive Order No. 21 (1965), as amended and Executive Order No. 39 (1991), "Prohibition in State Government of Discrimination Based on Sexual Orientation."

Any reported act of discriminatory behavior will be investigated through the Office of the Dean of Students, the Office of Compliance and Training, or the Office of Legal Affairs.

Sexual Harassment Policy

It is the continuing objective of the university to offer a work and study environment to its employees and students that rewards career and educational goals based upon relevant factors such as ability and work performance. Sexual harassment of employees and students is unacceptable. It is a barrier to educational and professional development and contrary to law and university policy.

In accordance with the NJIT Sexual Harassment Policy and Procedures, persons found to have violated university policy will face investigation, managerial review and possible disciplinary action up to and including termination.

Patent Ownership

NJIT retains proprietary interest in all inventions, discoveries, creative developments, trade secrets, and technical expertise developed by students who are attending or are employed by the university.

To protect against premature disclosure or publication of discoveries, students must immediately report them to the Office of Intellectual Property. Students must neither publish nor discuss discoveries with anyone other than the director of the Office of Intellectual Property or members of the university Patent Committee. When a project, thesis or dissertation covers such material, the student or the advisor must report the existence of such material to the Office of Graduate Studies and the Office of Intellectual Property; the university will expedite its review. If necessary, the Office of Graduate Studies and the Office of Intellectual Property will take steps to sequester patentable material in archival documents such as theses and dissertations. If the university applies for a patent, the student will sign an agreement specifying royalties, licensing, and sale. All income derived from discoveries will be shared between NJIT and the student. The size of the share is determined by university policy and/or special agreement.

For further information, call the Office of Intellectual Property (201) 596-2457.

Copyright Ownership

NJIT believes that its role as an educational institution is best served by disclosing to the public all academic research, dissertations and theses developed by students during the course of their studies or employment at the university.

Projects, theses and dissertations created by students shall be governed by the following provisions as outlined in NJIT's copyright policy under "Ownership and Disposition of Copyrightable Materials":

D. Copyright ownership of projects, theses and dissertations generated by research which is performed in whole or in part by the student with financial support in the form of wages, salaries, stipend or grant from funds administered by the Institute shall be determined in accordance with the terms of the support agreement, or in the absence of such terms, shall become the property of the Institute.

E. Copyright ownership of projects, theses and dissertations generated by research performed in whole or in part utilizing equipment or facilities provided to the Institute under conditions that impose copyright restriction shall be determined in accordance with such restrictions.

F. Copyright in projects, theses and dissertations not within the provisions of Categories D and E of this policy shall be the property of the author. However, the student must, as a condition of a degree award, grant royalty-free permission to the Institute to reproduce and publicly distribute copies of the project, thesis or dissertation.

Requests for permission to publish Category D and E should be addressed to the Office of Intellectual Property.

For further information, call the Office of Intellectual Property (201) 596-2457.

Property Loss

NJIT is not responsible for loss of property by fire or theft in its buildings or grounds.

Drug Abuse Prevention Program

New Jersey Institute of Technology discourages the use of illegal drugs. University policy concerning possession and consumption of alcoholic beverages on campus subscribes to strict enforcement of the laws of the State of New Jersey and the City of Newark. In addition, the policy stipulates that any consumption must occur within a responsible social framework wherein beverages are not the focus of the event.

Students with drug and alcohol abuse problems should be aware that they can receive information, counseling and referral assistance from the Office of the Dean of Student Services, the Counseling Center, the Health Services Office, or the Stop-In Center. The professional staff of the Counseling Center can provide substance abuse counseling and assessment in some situations and will refer more serious problems to off-campus facilities and services.

In addition, a series of educational programs focused on the areas of drug and alcohol information and substance abuse prevention are offered by the university through the Division of Student Services.

Drug-Free Workplace Policy Statement

New Jersey Institute of Technology is committed to maintaining a drug-free workplace in compliance with applicable laws. The university is further committed both to rigorous enforcement of applicable laws and policies and support for those trying to cope with drug-related problems. The unlawful possession, use, distribution, dispensation, sale or manufacture of controlled substances is prohibited on university premises. Any NJIT employee determined to have violated this policy or engaged in drug-related activities that have an impact upon the workplace may be subject to disciplinary action up to and including termination. At the discretion of the university, any employee convicted of a drug offense involving the workplace shall be subject to employee discipline (up to and including termination) and/or required to satisfactorily complete a drug rehabilitation program as a condition of continued employment.

The illegal use of controlled substances can seriously injure the health of employees, adversely affect the performance of their responsibilities, and endanger the safety and well-being of fellow employees, students, and members of the general public. Therefore, the university urges employees engaged in the illegal use of controlled substances to seek professional advice and treatment. Anyone who is employed at NJIT who has a drug problem is encouraged to contact the Director of the Employee Assistance Program (EAP), who will assist in obtaining available treatment. Employees engaged in contracts with the U.S. Department of Defense are additionally subject to Department of Defense requirements and may be required to submit to tests for the illegal use of controlled substances.

As a condition of employment, an employee of NJIT will notify his/her supervisor if he or she is convicted of a criminal drug offense involving the workplace within five days of the conviction. In the event any such conviction involves an employee working on a federal contract or grant, the university will notify the granting or contracting federal agency within ten days of receiving notice of a conviction. A copy of this statement shall be given to all employees.

This statement and its requirements are promulgated in accordance with the requirements of the Drug-Free Workplace Act of 1988 enacted by the United States Congress. The university will continue its efforts to maintain a drug-free environment by adhering to the above policy and by providing through the EAP and the offices of Human Resources, and Compliance and Training, ongoing drug awareness programs.

Degree Programs

Applied Physics

Administered by: Federated Physics Department of NJIT and Rutgers-Newark

Federated Chairperson and Chairperson (NJIT): Anthony M. Johnson
Chairperson (Rutgers-Newark): Earl D. Shaw
Associate Chairperson (NJIT): Frederick Tomblin
Distinguished Professors: Goode, Levy, Poate
Professors: Buteau, Carr, Chin, Fink, Gautreau, Johnson, Savin
Associate Professors: Ravindra, Russo, Stevenson, Towfik
Assistant Professors: Farmer, Federici, Jermakian, O. Reisman, Tyson, H. Wang
Distinguished Research Professor: Hensel
Research Professors/Special Lecturers: Kohn, Moeller, Opyrchral, Piatek, Tomblin

Rutgers-Newark Faculty
Professor Rank II: Daniel E. Murnick
Professor: Shaw
Associate Professors: Li, Wu
Assistant Professor: Burke

Graduate Advisor: Ken K. Chin (201) 596-3297 (Room 466TIE); e-mail chin@admin.njit.edu

Degrees Offered: Master of Science in Applied Physics; Doctor of Philosophy in Applied Physics. Both degrees are offered jointly by NJIT and Rutgers-Newark.

■ MASTER OF SCIENCE IN APPLIED PHYSICS

The program is for students with an undergraduate degree in physics, applied physics, or engineering, who wish to apply physics to optical science, microelectronics, materials science, surface science, solar phenomena, and other related areas.

Admission Requirements

A bachelor's degree in physics, applied physics, or related areas from an accredited institution is required. An undergraduate GPA above 3.0 is required. Students must submit scores on the GRE aptitude section. In addition, applicants are required to provide three letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550.

Degree Requirements

A minimum of 30 degree credits (above 600 level), including a 6-credit thesis or a 3-credit project is required. Of the 30 credits, 18 must be physics courses (including mathematical physics or applied mathematics). The remaining 12 to 15 credits are elective courses.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in Phys 791/26:755:791 Applied Physics Seminar.

REQUIRED
12 credits:
Phys 611/26:755:611 Classical Mechanics
Phys 621/26:755:621 Classical Electrodynamics I
Phys 631/26:755:631 Quantum Mechanics I
Phys 641/26:755:641 Statistical Mechanics

PROJECT OR THESIS (required)
3 credits: Phys 700/26:755:700 Master's Project *or*
6 credits: Phys 701/26:755:700 Master's Thesis

ELECTIVE
12 to 15 credits:
Selected in consulation with a graduate advisor.

■ DOCTOR OF PHILOSOPHY IN APPLIED PHYSICS

This program is for superior students in applied physics who are interested in and committed to scholarly research.

Admission Requirements

Applicants are expected to have a master's degree in physics, applied physics, or related engineering disciplines from an accredited institution. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. A GPA of at least 3.5 in undergraduate and previous graduate studies is normally required for admission. The GRE aptitude and advanced (physics) sections scores are required. Applicants are required to provide three letters of recommendation from their previous academic institutions. Students for whom English is not their native language are required to have TOEFL scores no lower than 550.

Degree Requirements

For students entering with B.S. or B.A. degrees, the degree requires 75 (above 600 level) credits: 39 credits are course work, and 36 credits are dissertation research. Among the course work, 24 credits are physics courses (including mathematical physics or applied mathematics), and 15 credits are electives. No less than 12 credits must be at the 700-doctoral level.

For students entering with M.S. or M.A. degrees, the degree requires 54 (above 600 level) credits: 18 credits are course work, and 36 credits are dissertation research. Among the course work, 9 credits are physics courses (including mathematical physics or applied mathematics), and 9 credits are electives. No less than 12 credits must be at 700-doctoral level.

Seminar—All doctoral students must enroll in Phys 791/26:755:791 Applied Physics Seminar each semester, including each semester they are enrolled in Phys 790/26:755:790 Doctoral Dissertation and Research.

REQUIRED
18 credits:
Phys 611/26:755:611 Classical Mechanics
Phys 621/26:755:621 Classical Electrodynamics I
Phys 631/26:755:631 Quantum Mechanics I
Phys 641/26:755:641 Statistical Mechanics
Phys 721/26:755:721 Classical Electrodynamics II
Phys 731/26:755:731 Quantum Mechanics II

The four 600-level physics courses can be waived for entering students who have M.S. degrees and have taken the courses in the master's program.

Qualifying Examination—The student must pass a written and oral qualifying examination. The written qualifying exam is administered yearly to test general academic preparation and competence in the research of applied physics. Within one year after passing the written qualifying exam, the student is required to pass the oral qualifying exam, in which the potential Ph.D. candidate presents a preliminary research proposal for approval by the dissertation committee.

Dissertation and Oral Defense—An oral presentation and defense of the doctoral dissertation is required. A five-member committee, chaired by the dissertation advisor, must approve the content and presentation of the dissertation research.

Applied Science

Administered by: Applied Science Committee

Program Director and Graduate Advisor: Leon Buteau (201) 596-3677, e-mail buteau@admin.njit.edu

Degree Offered: Master of Science in Applied Science

■ MASTER OF SCIENCE IN APPLIED SCIENCE

A multidisciplinary program for secondary school teachers to strengthen their backgrounds in science and mathematics.

Admission Requirements

Applicants should be practicing secondary school teachers who have bachelor's degrees. Individuals who seek admission to the program in order to teach are considered for admission on an individual basis. Students who lack an appropriate background in science may be asked by the department to take an individually-designed program of courses (that may include undergraduate courses) before beginning their graduate curriculum. These courses are not counted toward degree requirements.

Degree Requirements

Students must select one of four areas of specialization. Advisors in each area of specialization will assist students in planning a program of study. A minimum of 36 degree credits is required including core, required and elective courses. A student may, with the advisor's approval, choose a coherent set of three or more courses in a non-major field and receive a minor in that field.

CORE

9 credits of pedagogy courses, offered by arrangement with another university to be designated.

AREAS OF SPECIALIZATION

Biology

REQUIRED
15 credits of courses in genetics/biochemistry, cell biology, microbiology, organismic biology, and ecology courses, offered by arrangement with another university to be designated.

ELECTIVE
12 credits selected in consultation with advisor

Chemistry

REQUIRED
9 credits as follows:
Chem 624 Modern Organic Chemistry
Chem 661 Instrumental Analysis
Chem 673 Biochemistry
7 credits of courses in: modern chemistry and applied physical chemistry courses, offered by arrangement with another university to be designated.

ELECTIVE
11-12 credits selected in consultation with advisor

Mathematics

REQUIRED
6 credits as follows:
Math 521 Applied Analysis
Math 611 Numerical Methods for Computation
6 credits of courses in: graph theory and statistics courses, offered by arrangement with another university to be designated.

ELECTIVE
15 credits selected in consultation with advisor

Physics

REQUIRED
15 credits, see advisor

ELECTIVE
12 credits selected in consultation with advisor

Architecture

Administered by: School of Architecture

Dean: Urs P. Gauchat
Associate Dean: James E. Dyer
Graduate Program Director: Peter C. Papademetriou
Graduate Program Assistant Director: Timothy Wood
Infrastructure Planning Program Director: Antonio de Souza Santos
Sponsored Chair: Ezra Ehrenkrantz
Distinguished Professor: Mostoller
Professors: Celik, Ehrenkrantz, Gauchat, Goldman, Greenfield, Hawk, Papademetriou, Santos, Schuman
Associate Professors: Elwell, Franck, Hewitt, Jackson, Moore, Wall, Weisman, West, Zdepski
Research Professor: Bales

Graduate Advisor: Peter C. Papademetriou (201) 596-3078, e-mail m-arch@admin.njit.edu
MSAS Graduate Advisor: David Hawk (201) 596-3019
Co-op Faculty Advisor: Timothy Wood

Degrees Offered: Master of Architecture (professional and post-professional options); Master of Science in Architectural Studies; Master in Infrastructure Planning; and dual Master of Architecture (professional, or post-professional) and Master of Science in Management or Master in Infrastructure Planning

An architect today must be educated to design most of the physical and environmental fabric of our built world. Professional design skills enhance the building process. Design informs our quality of life. Architects advocating the social value of the building process can transform ideals into reality.

Design and technology are complementary. Science reveals existing orders of the natural world; the aim of design and technology is the adaptation of these principles for the good of humanity. Design is synthesis and creates order in the environment. Design is a process whereby facts and values are unified in the creation of our built culture.

The Architecture graduate program offers several options for students having various levels of experience in the field. The richness of course offerings in the professional degree program allows students to pursue focused studies in building sciences, community and urban design, and history/theory. It permits flexibility in developing individual interests within the various curriculum structures. Post-professional opportunities for new career directions, scholarly inquiry and research are also offered through degree programs in architectural studies and infrastructure planning.

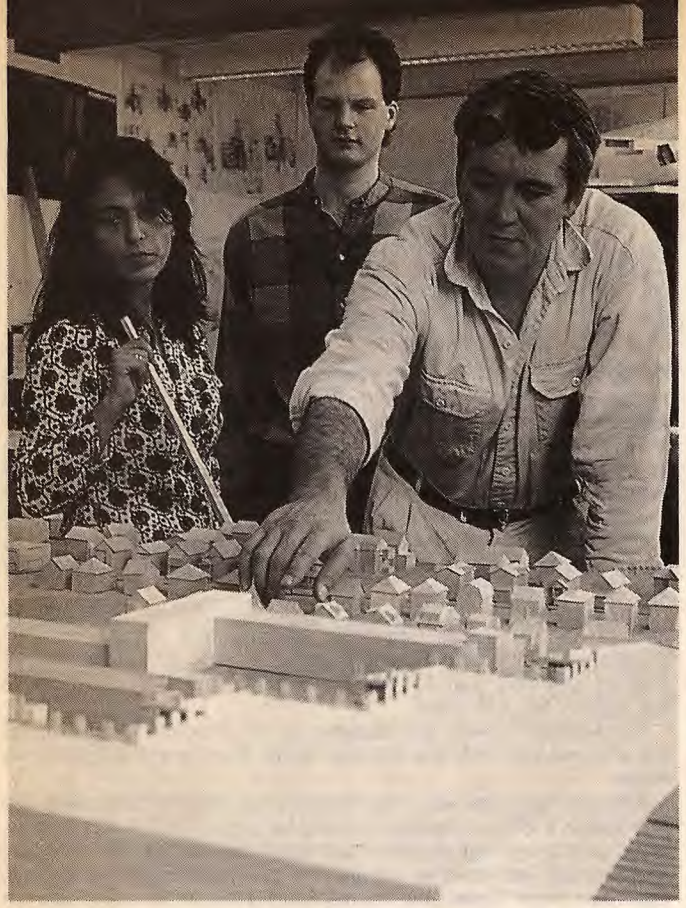
The NJIT School of Architecture is the only publicly-supported professional program in New Jersey and is committed to the university's reputation as a nationally recognized technological university.

The faculty comprises scholars and practitioners whose expertise represents both breadth and depth of achievement and professional reputation. Their work directly engages the architectural discourse through research, publication, public lectures, and professional program and symposia. Many members have received scholarly and design awards.

To become registered as a licensed architect in the State of New Jersey, you must earn a degree accredited by the National Architectural Accrediting Board (NAAB). NJIT's M.Arch. degree program is one of only two NAAB-accredited degree programs in the State of New Jersey.

The following statement by NAAB defines criteria and procedures for degrees in architecture:

Most states [including the State of New Jersey] require that an individual intending to become an architect hold an accredited degree. There are two types of degrees that are accredited by the National Architectural Accrediting Board: (1) The Bachelor of Architecture, which requires a minimum of five years of study, and (2) The Master of Architecture, which requires a minimum of three years of study following an unrelated bachelor's degree or two years following a related pre-professional bachelor's degree. These professional degrees are structured to educate those who aspire to registration/licensure as architects. Four year degree, where offered, is not accredited by NAAB but may be considered as a pre-professional degree for students applying to NJIT. The professional degree is useful for those wishing a foundation in the field of architecture, as preparation for either continued education in a professional degree program or for employment options in architecturally related areas.



■ MASTER OF ARCHITECTURE (M.Arch.)

Fulfilling requirements for the M.Arch. degree requires full-time study for at least one year, and possibly more.

There are two degree options in the M.Arch. program: professional M.Arch. and post-professional M.Arch.

Professional M.Arch. For students with undergraduate or graduate degrees who do not have previous architectural design courses or experience. It is also appropriate for students who have undergraduate degrees in architecture or related fields, those who have a non-NAAB accredited architecture degree, and all international students. Advanced placement for students is determined at the time of admission through an evaluation of previous academic work. Advanced placement reduces the 97-credit degree requirement.

Post-professional M.Arch. For students who have an NAAB-accredited professional Bachelor of Architecture (B.Arch.) degree.

Dual Degree M.Arch. and Master of Infrastructure Planning (M.I.P.) Open only to students in the professional M.Arch. program, the dual degree program permits students to obtain an M.I.P. in substantially less time than if taken separately. Also see the program description under "Infrastructure Planning" in this catalog.

Dual Degree M.Arch. and M.S. in Management Open only to candidates in both M.Arch. options, the dual degree program permits students to obtain an M.S. in Management in substantially less time; in some cases in only one more semester of full-time study.

Admission Requirements for all M.Arch. Options

In addition to completing forms required by NJIT's Office of University Admissions, M.Arch. applicants must also submit School of Architecture supplementary application forms and materials. To ensure prompt consideration, students should request these materials at the time they first apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. Graduate Record Examinations (GRE) scores are required. Applicants to the M.Arch./M.S. in Management degree option may submit GRE scores in lieu of the Graduate Management Admission Test scores which are normally required for admission to the Master of Science in Management program. Otherwise, dual degree applicants must satisfy admission requirements for both the School of Architecture and School of Industrial Management (SIM).

Admission to the M.Arch. program is based on the applicant's personal statement, letters of recommendation, design portfolio and previous academic and work experience. Applicants should demonstrate undergraduate course work in physics, calculus, or calculus/statistics. Students who lack the appropriate academic background will be expected to take equivalent course work before entering the second year of the M.Arch. program.

International Applicants Test of English as a Foreign Language (TOEFL) scores are required for all international students.

Degree Requirements for Professional M.Arch.

This 97-credit program consists of a 61-credit core and 36 credits of required and elective courses within an options sequence. Candidates are expected to complete the core sequence in a minimum of two years. Before registering for courses, all students must consult with the graduate advisor to plan an appropriate course of study.

Students must submit a portfolio of design work at completion of core courses. The portfolio will be reviewed in connection with advising students on their further program of study.

Core courses in the M.Arch. represent the minimum background necessary to meet NAAB standards. If students demonstrate that they already have taken equivalent course work, degree credit requirements may be reduced below the 97 credits for those required for the program. After completing core course work, students select 9 credits of architectural electives and 6 credits of free electives in consultation with the graduate advisor.

To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses. Students must repeat any design studio course in which they receive a grade of "C." A grade of "C+" in any design studio must be followed by a subsequent grade sufficient to raise the cumulative design studio GPA to 2.75. Incomplete ("I") grades for studio and prerequisite courses must be removed before students will be permitted to register for continuing course work in the program.

Degree credits appear in parentheses following the course titles below.

CORE

61 credits as follows:

Arch 500G Computer Programming and Graphics Problems (2)
Arch 501G Architectural Design I (5)
Arch 502G Architectural Design II (5)
Arch 503G Architectural Design III (5)
Arch 504G Architectural Design IV (5)
Arch 511G Structures I (3)
Arch 512G Structures II (3)
Arch 513G Structures III (3)
Arch 521G Construction I (3)
Arch 522G Construction II (3)
Arch 523G Building Performance (3)
Arch 524G Environmental Control Systems (3)
Arch 528G History of Architecture I (3)
Arch 529G History of Architecture II (3)
Arch 555G Architectural Graphics (3)
**Arch 569G Building and Development (3)
6 additional credits of Architectural History, selected in consultation with graduate advisor

Core courses must be completed before proceeding to areas of concentration.

OPTIONS SEQUENCE

REQUIRED

21 credits minimum:

Arch 579G Professional Architectural Practice (3)
Arch 505G Advanced Design Options I (6)
Arch 506G Advanced Design Options II (6)
{ Arch 507G Advanced Design Options III (6), *or*
{ *MARC 701 Master of Architecture Thesis (7)

ELECTIVE

15 credits selected in consultation with graduate advisor.

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*Arch 661 Directed Studies of Architecture (3) is prerequisite for MARC 701 Master of Architecture Thesis. Arch 661 may be taken as an elective.

**pending

Degree Requirements for Post-Professional M.Arch.

Consists of a minimum of 30 credits. Thesis is optional.

REQUIRED

12 credits minimum:

Arch 506G	Advanced Design Options II (6)
Arch 507G	Advanced Design Options III (6), *or*
*MARC 701	Master of Architecture Thesis (7)

ELECTIVE

18 credits consisting of 12 credits of architectural electives and 6 credits of free electives selected in consultation with graduate advisor.

Degree Requirements for Dual M.Arch. and M.I.P.

This dual degree option is available to students in the professional M.Arch. degree program. The dual degree program permits students to obtain the M.Arch. and the M.I.P. in substantially less time than if each degree were pursued separately. M.Arch. students may partially fulfill M.I.P. course work while completing the M.Arch. program of study. A maximum of 21 credits may be used to satisfy requirements of both degrees.

For more information about the M.I.P. program, see "Infrastructure Planning" in this catalog.

REQUIRED

21 credits:

Arch 507G	Advanced Design Options III (fulfills MIP 601) (6)
Arch 579G	Professional Architectural Practice (fulfills MIP 691) (3)
Arch 631H	History and Theory of Urban Infrastructure (fulfills MIP 631) (3)
Arch 673	Introduction to Infrastructure Planning (fulfills MIP 673) (3)
Arch 674	Infrastructure and Architecture (fulfills MIP 674) (3)
Arch 675	Elements of Urban Infrastructure (fulfills MIP 675) (3)

Additional requirements to complete M.I.P. program

REQUIRED

30 credits:

MIP 602	Infrastructure Technology Studio II (6)
MIP 603	Interdisciplinary Infrastructure Studio III (6)
**MIP 612	Introduction to Environmental Policy (3)
**MIP 618	Public and Private Financing of Urban Areas (3)
**MIP 643	Introduction to Urban Transportation Planning (3)
MIP 650	Urban Systems Engineering (3)
MIP 668	Development of Urban Planning (3)
MIP 669	Infrastructure Financing and Strategy (3)

Degree Requirements for Dual M.Arch. and M.S. in Management

The dual degree option is only available to students pursuing the M.Arch. degree. The dual degree program permits students to obtain a Master of Science in Management in substantially less time; in some cases in only one more semester of full-time study.

Students take additional credits shown below to fulfill requirements for the M.S. in management. There is no thesis requirement.

At the time of admission to the dual degree program, the SIM graduate advisor will determine if any M.S. in Management course requirements can be waived.

The requirements to obtain the M.S. in Management degree are:

†**CORE**

18 credits:

Arch 650	Economy of Building
Arch 651	Real Estate Analysis
Arch 652	Architectural Project Management
Fin 516	Principles of Financial Management
HRM 601	Organizational Behavior
Mgmt 680	Entrepreneurial Strategy *or*
Mgmt 692	Business Strategy

ELECTIVE

12 credits from:

Acct 615	Concepts of Strategic Cost Analysis
Fin 618	Public and Private Financing of Urban Areas
Fin 624	Financial Management
Mgmt 640	New Venture Management
Mgmt 645	New Venture Finance
MIS 645	MIS Operations, Management, Planning and Control
Mrkt 630	Models of Consumer Behavior
Mrkt 638	Sales Management for Technical Professionals

Co-op Internship in Architecture and **Housing Fellows** give students an opportunity to gain additive degree credit and salaried employment that can be applied towards state architecture licensing requirements.

To become eligible to take the architecture licensing examination in New Jersey, professional M.Arch. graduates must complete three years of work experience that meet specific criteria set by the state licensing board. Co-op internship work experiences in architecture are acceptable equivalents for such apprenticeships and are available to NJIT students. Students become eligible after completing the first year of M.Arch. core courses.

Housing Fellows are placed with community-based, non-profit organizations that initiate affordable housing and related projects. Graduate students who have completed at least 28 credits of core courses and who have an overall cumulative GPA of 3.2 or above are eligible to participate.

The program is jointly administered by the Office of Community and Public Service (OCPS) and the New Jersey Department of Community Affairs.

Students apply through the Office of Cooperative Education and Internships and if they comply with the various School of Architecture, state, and co-op requirements and are accepted into the program, students are permitted to register for the Architecture Cooperative Education Work Experience course. Credits are additive and are not in lieu of required course work.

Students should consult the School of Architecture Co-op graduate advisor for details on apprenticeships.

■ MASTER OF SCIENCE IN ARCHITECTURAL STUDIES (MSAS)

A non-professional, non-design degree program for careers in architectural research and scholarship. Studies often involve interdisciplinary course work.

Admission Requirements

Applicants are expected to have either an NAAB-accredited B.Arch., B.S., B.A. in architecture, or disciplines related to production, operation or use of buildings.

In addition to completing forms required by NJIT's Office of University Admissions, applicants must also submit School of Architecture supplementary application forms and materials. To ensure prompt consideration, students should request these materials at the time they first apply for admission to the university.

Applicants are expected to have a minimum undergraduate GPA of 3.0. Graduate Record Examinations (GRE) scores are required.

Degree Requirements

The program consists of 40 credits of required and elective courses that may be taken either full- or part-time. A thesis is required. Students are expected to design their programs in consultation with the graduate advisor.

To remain in good academic standing, students must maintain a cumulative GPA of 3.0 in graduate courses.

REQUIRED

22 credits:

Arch 661	Directed Studies of Architecture (3)
Arch 686	Research Methods for Environmental Design (3)
Eng 541	Advanced Technical and Research Report Writing (3)
Math 687	Quantitative Analysis for Environmental Design Research (3)
MSAS 701	Master of Science in Architectural Studies Thesis (10)

ELECTIVES

18 credits selected in consultation with the M.S.A.S. graduate advisor.

■ MASTER IN INFRASTRUCTURE PLANNING

See "Infrastructure Planning" in this catalog for program description.

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*Arch 661 Directed Studies of Architecture (3) is prerequisite for MARC 701 Master of Architecture Thesis. Arch 661 may be taken as an elective.

**Course can be taken as an architectural elective.

†For those pursuing the dual M.Arch. and M.S. in Management, Arch 579G fulfills Mgmt 691 Legal and Ethical Issues required for the M.S. in Management.

Biomedical Engineering

Administered by: Biomedical Engineering Committee

Program Director: David Kristol
Associate Program Director: Stanley Reisman

Graduate Advisor: David Kristol (201) 596-3584 (Room 363TIE), e-mail kristol@admin.njit.edu

Degree Offered: Master of Science in Biomedical Engineering

■ MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

The M.S. in Biomedical Engineering stresses the application of the principles and practices of engineering, science and mathematics in solving clinical problems in medicine and surgery. Biomedical engineering students can concentrate on the chemical, computer, electrical, industrial or mechanical engineering aspects of biomedical engineering. Major research areas include modeling, simulation and analysis in the areas of cardiovascular dynamics; signal processing of electrocardiograms, electroencephalograms, and electromyograms; clinical image processing; and the design and analysis of clinical instrumentation and prosthetic devices such as knees, heart valves, hips, voice boxes, and ostomy devices.

Research is conducted cooperatively between NJIT and the medical and dental schools of the University of Medicine and Dentistry of New Jersey, the Kessler Institute for Rehabilitation, St. Barnabas Medical Center, Veteran's Administration Medical Center in East Orange, and several hospitals in the New Jersey-New York metropolitan area. In addition, cooperative research opportunities exist with a number of biomedical and pharmaceutical companies within a short commuting distance from NJIT.

Admission Requirements

Applicants are expected to have an undergraduate degree in science or engineering and courses in thermodynamics, differential equations, computer programming, electrical engineering principles, and statics or dynamics.

Bridge Program—Students who lack an appropriate background are required to make up deficiencies before beginning their graduate curriculum. The program of courses is designed in consultation with graduate advisors and may include undergraduate courses. These courses are not counted toward degree requirements.

Degree Requirements

Students must take at least 30 course credits: 18 required, including a thesis; and 12 electives. At the discretion of a student's graduate advisor, appropriate courses offered at the University of Medicine and Dentistry of New Jersey may also be taken as electives. See current UMDNJ catalog for course descriptions.

Seminar—In addition to the minimum 30 degree credits required, all students receiving program or research-based awards must enroll each semester in BME 791 Seminar in Biomedical Engineering.

REQUIRED
9 credits as follows:
*BME 669 Quantitative Physiology for Engineers
ChE 627 Introduction to Biomedical Engineering
EE 667 Systems Studies in Bioengineering
3 credits:
ME 671 Biomechanics of Human Structure and Motion *or*
BME 672 Biomaterials

THESIS (required)
6 credits: BME 701 Thesis in Biomedical Engineering

ELECTIVE
12 credits from the following or other courses approved by the director:
ChE 624 Transport Phenomena I
ChE 626 Mathematical Methods in Chemical Engineering
ChE 645 Fundamentals of Rheology
Chem 673 Biochemistry
CIS 653 Microcomputers and Applications
CIS 655 Minicomputer Systems
CIS 661 Systems Simulation
EE 601 Linear Systems
EE 673 Random Signal Analysis I
EE 684 Advanced Microprocessor Systems
EE 686 Instrumentation Systems and Microprocessors
EE 687 Design of Microprocessor-Based Medical Instrumentation
IE 661 Man-Machine Systems
IE 669 Human Design Factors in Engineering
Math 651 Applied Math I
Math 661 Mathematical Statistics I
Math 673 Biomathematics II: Pattern Formation in Biological Systems
ME 622 Finite Element Methods in Mechanical Engineering
ME 632 Instrumentation
ME 635 Computer-Aided Design

*Students who have passed an undergraduate course in physiology are exempt from BME 669, but must take another course in its place.

Biomedical Informatics

Administered by: Department of Computer and Information Science, NJIT, and School of Health Related Professions, UMDNJ

Program Director: Syed Haque (UMDNJ) (201) 982-6871; e-mail haque@umdnj.edu

Associate Program Director: Peter Ng (NJIT) (201) 596-3387 (Room 4410 GITC), e-mail ngp@admin.njit.edu

Degrees Offered: Master of Science in Biomedical Informatics; Doctor of Philosophy in Biomedical Informatics (pending approval), both degrees are conferred jointly by NJIT and the University of Medicine and Dentistry of New Jersey.

■ MASTER OF SCIENCE IN BIOMEDICAL INFORMATICS

Biomedical informatics is the study of the storage, archiving, retrieving, and utilization of medical information. It covers a broad spectrum of information relating to the field of health care, including, but not limited to, hospital billing, medical education, clinical laboratory data management, medical and surgical diagnoses, and medical imaging. The master's program prepares students to apply computer and information sciences to support and manage health care and hospital management systems, laboratory automation, quality assurance, resource allocation, biomedical research, clinical decision making, and treatment.

Admission Requirements

Applicants are expected to have an undergraduate degree in any field of health sciences (including medicine, dentistry, allied health, nursing, public health, pharmacy), biological sciences, computer science, engineering or equivalent field of study.

Bridge Program—Students are expected to have basic proficiency in any programming language, database concepts, elementary calculus and differential equations. Those who lack this background will be expected to take UMDNJ's BINF:4000 Essentials of Health Computer Science or its equivalent. Students who lack academic backgrounds in health science disciplines will be required to take a course in engineering physiology or an equivalent.

Graduate Certificate Program—A 12-credit graduate certificate in Health Care Information Systems is available as a step toward this degree. Students can complete this certificate in part through classes conducted via electronic communications. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

Students must complete 36 degree credits: 18 in required core courses; 6 in an area of emphasis; 6 in electives (in consultation with an advisor); and 6 of thesis. Courses are offered at NJIT and the University of Medicine and Dentistry of New Jersey.

Seminar—In addition to the minimum 36 degree credits required, all students who receive departmental or research-based awards must enroll each semester in BINF 615/BINF 5150 Seminar: Biomedical Teaching Systems Design or equivalent.

CORE

18 credits:

BINF 600/BINF 5100	Introduction to Biomedical Informatics
BINF 601/BINF 5005	Health Care Information Systems
BINF 602/BINF 5020	Biomedical Modeling and Decision-Making Systems
BINF 603/BINF 5030	Visualization in Biomedical Sciences
BINF 621/BINF 5210	Research Methods in the Health Sciences
CIS 610	Data Structures and Algorithms

THESIS (required)

6 credits: BINF 6000 Directed Research/Project

AREAS OF EMPHASIS

6 credits: Choose either "Group 1" or "Group 2."

Group 1: Health Information Decision Support Systems

BINF 612/BINF 5125	Clinical Problem Solving and Decision-Making *and*
BINF 613/BINF 5130	Health Care Decision Support Systems *or*
CIS 631	Data Management System Design

Group 2: Health Sciences Teaching Systems

BINF 631/BINF 5311	Intelligent Instructional Systems *and*
BINF 632/BINF 5312	Interactive Learning Systems for the Health Sciences *or*
CIS 658	Multimedia Systems

ELECTIVE

6 credits: Choose two courses.

BINF 614/BINF 5135	Clinical Systems Interface Design *or*
CIS 688	Programming for Interactive Environments
BME 669	Quantitative Physiology for Engineers
CIS 632	Advanced Database System Design
CIS 634	Information Retrieval
CIS 650	Computer Architecture
CIS 652	Computer Networks—Architectures, Protocols and Standards
CIS 654	Telecommunication Networks Performance Analysis
CIS 656	Internetworking and Higher Layer Protocols
CIS 671	Knowledge-Based Systems
CIS 672	Expert System Methods and Design
MIS 648	Decision Support Systems

■ DOCTOR OF PHILOSOPHY IN BIOMEDICAL INFORMATICS (pending approval)

The degree provides students with expertise in the storage, archiving, retrieval and utilization of the entire scope of medical information ranging from medical image technology through clinical information systems, medical decision making and others. It educates biomedical informatics professionals and scholars who will continue to explore the synergism between computer science and the nation's health care delivery system in the forefront of research and development in this field of knowledge. Upon completion of the program, students will be able to develop and apply theories and techniques of biomedical informatics for designing, testing and evaluating structures and algorithms, conversion of scientific data into biomedical knowledge, with a thorough understanding of the processes of conversion and the properties of medical information.

Admission Requirements

The joint Ph.D. program in biomedical informatics will meet both NJIT and UMDNJ requirements. Students must hold an undergraduate or graduate degree in a health field or biomedical informatics, computer science, engineering or a related field from an accredited institution, with a minimum GPA of 3.5. Students must submit: official baccalaureate and master's degree transcripts, curriculum vitae, three letters of recommendation, and GRE/GMAT/MCAT/DAT or comparable graduate admission examination scores. International students must demonstrate proficiency in the English language by scoring a minimum of 550 on the TOEFL.

In addition, applicants must demonstrate superior performance in: a programming language, database concepts, mathematics corresponding to the content of CIS 431, CIS 505, Math 111, Math 121, and Math 211 (Students who fail to demonstrate performance in these areas will be required to take prerequisite courses.); a sequence of courses in biomedical informatics; and documented aptitude, interest and commitment to scholarly activities and research (demonstrated by quality of papers, projects completed by student, letters of recommendation submitted by persons familiar with the student's academic work).

Students may be admitted either through NJIT or through UMDNJ by a Committee of Admissions consisting of equal number of members from both NJIT and UMDNJ. Student records will be archived by the institution through which they are admitted.

Candidacy Requirements—Admission to the doctoral program does not imply candidacy for a degree. To be admitted to candidacy, student must: pass the qualifying examination of preparatory studies in the area of biomedical informatics theory and systems, as well as selected Biomedical Informatics courses, related to the area of student's interest; successfully complete the advanced courses related to the student's expected research area of specialization; and submit and defend successfully a dissertation proposal. Registration for dissertation research will be permitted to those who have passed the qualifying examination.

Degree Requirements

The curriculum requires completion of at least 60 credits beyond the master of science degree; and maintenance of a cumulative graduate GPA of 3.0 or better, and with no more than two grades of C. In addition to meeting degree requirements, students are expected to assist in teaching at least one course in biomedical informatics or related area, under the supervision of a faculty member.

REQUIRED

At least *24 credits* of advanced courses at the 600 level [6000 level at UMDNJ] subject to advisor's approval and related to the expected research area of specialization; 12 credits must be at the 700 level [7000 level at UMDNJ].

36 credits of dissertation research culminating in a dissertation which meets the publication requirements of both UMDNJ and NJIT. A maximum of 6 credits may be at the 700 level [7000 level at UMDNJ] pre-doctoral research level, culminating in a dissertation proposal. The proposal must be successfully defended. These credits may be applied to the dissertation credits.

Participation in the graduate colloquium/seminars, BINF 5150 Seminar: Biomedical Teaching Systems Design or CIS 791 Doctoral Seminar, each semester.

Submission of the final draft of the dissertation with successful dissertation defense.

In addition to the dissertation, submission of at least one research paper for publication in a peer reviewed journal.

Qualifying Examination—Students must pass a doctoral qualifying examination, which is designed to test the fundamental knowledge of all students in the area of biomedical informatics theory and systems, as well as selected Biomedical Informatics courses related to the area of specialization.

Oral Examination—The dissertation must be defended in an oral examination.

Chemical Engineering

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Associate Chairpersons: Carol Venanzi (chemistry), Reginald Tomkins (undergraduate programs), Richard Trattner (environmental science)
Sponsored Chair: Kamalesh Sirkar (membrane separations and biotechnology)
Chemical Engineering Division
Distinguished Professors: Lewandowski, Sirkar
Professors: Armenante, Baltzis, Greenstein, Hanesian, Huang, Magee, Perna, Pfeffer, Roche, Sofer
Associate Professors: Barat, Knox, Loney, Xanthos
Assistant Professors: Bart, Luo
Research Professor: Shaw
Graduate Recruiter: Dana Knox (201) 596-3599, e-mail knoxd@admin.njit.edu
Graduate Advisor: Robert Barat (201) 596-5605, e-mail barat@admin.njit.edu

Degrees Offered: Master of Science in Chemical Engineering; Degree of Engineer; Doctor of Philosophy in Chemical Engineering

■ MASTER OF SCIENCE IN CHEMICAL ENGINEERING

A program of advanced studies in chemical engineering for individuals with undergraduate chemical engineering degrees who wish to specialize in a specific area or prepare for more advanced degrees.

Admission Requirements

Normally an undergraduate degree in chemical engineering is required. Students who have a degree in either chemistry or another engineering discipline may be required to take an individually designed program that may include undergraduate courses before beginning their graduate curriculum. These courses are not counted toward degree credit.

A minimum undergraduate grade point average (GPA) of 3.0 on a 4.0 scale, or equivalent, is normally required for admission. Graduate Record Examinations (GRE) scores must be submitted. International students must also submit scores in the Test of English as a Foreign Language (TOEFL). International students applying for financial support must achieve a minimum TOEFL score of 550.

Degree Requirements

A minimum of 30 degree credits is required. Students must attain a minimum GPA of 3.0 in core courses listed below, and a minimum overall GPA of 3.0.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in ChE 791 Graduate Seminar, which does not count toward degree credits.

CORE
12 credits as follows:
ChE 611 Thermodynamics
ChE 612 Kinetics of Reactions and Reactor Design
ChE 624 Transport Phenomena I
ChE 626 Mathematical Methods in Chemical Engineering

THESIS
Required of those receiving departmental or research-based support; others may choose a minimum of 6 credits of 600- or 700-level courses in chemical engineering or chemistry instead of thesis.
6 credits: ChE 701 Master's Thesis

ELECTIVE
6 to 12 credits from 600- or 700-level courses in chemistry or chemical engineering

3 credits from 600- or 700-level courses. May be from outside chemistry or chemical engineering.

3 credits from 500- or 600-level courses. May be from outside chemistry or chemical engineering.

■ DOCTOR OF PHILOSOPHY IN CHEMICAL ENGINEERING

This is a research-oriented degree normally intended for full-time students. Although, initially, courses may be taken on a part-time basis, a minimum of one year of full-time residency is required for completion of a dissertation.

Admission Requirements

Normally, a master's degree in chemical engineering is required. In exceptional circumstances, highly qualified students with bachelor's degrees in chemical engineering may be accepted directly into the doctoral program.

A minimum master's grade point average (GPA) of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. GRE scores must be submitted. International students must also achieve a minimum TOEFL score of 550.

Degree Requirements

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Students must attain a minimum overall GPA of 3.0. A minimum of 36 credits of ChE 790 Doctoral Dissertation and Research, and registration every semester for ChE 791 Graduate Seminar, are required. Should the 36 credits of ChE 790 be completed before submission of the final dissertation document, students must register for a minimum of 3 credits of ChE 790 each semester until it has been submitted and accepted. In addition, at least 24 credits of course work beyond the master's degree are required, of which 12 credits must be at the 700-level.

For the required 700-level courses, 6 credits must be in chemical engineering or chemistry. No more than 3 credits may be in Independent Study (ChE 705 or Chem 705).

Qualifying Examination—All applicants are expected to pass a qualifying examination that tests general competence in chemical engineering, chemistry, and mathematics at the master's level. It must be taken within the first year following admission to the program, and passed within two years. The examination is offered every January and June. A student will be allowed only two attempts to pass the examination.

Formation of Thesis Committee—Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not thesis or dissertation advisor) in chemical engineering. As a minimum, the committee must consist of the doctoral student's advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal—Within six months of forming the dissertation committee, doctoral students must make an oral presentation to their committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months (i.e. doctoral students must have an approved dissertation committee, and an approved dissertation proposal, within a year of passing the qualifying examination).

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Admission and Degree Requirements for Exceptional Candidates with Bachelor's Degree Only

Exceptional students with undergraduate degrees in chemical engineering may apply directly for admission to the doctoral program. Applicants are evaluated on a case-by-case basis. A minimum undergraduate grade point average (GPA) of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Students must attain a minimum GPA of 3.0 in the core courses (ChE 611, ChE 612, ChE 624, and ChE 626), and a minimum overall GPA of 3.0.

REQUIRED

48 credits as follows:

ChE 611 Thermodynamics
ChE 612 Kinetics of Reactions and Reactor Design
ChE 624 Transport Phenomena I
ChE 626 Mathematical Methods in Chemical Engineering
ChE 790 Doctoral Dissertation and Research
ChE 791 Graduate Seminar (not counted toward degree credit)

ELECTIVE

12 credits from 700-level courses. 6 credits must be in chemical engineering or chemistry. None of these 6 credits may be in Independent Study (ChE 705 or Chem 705). Of the remaining 6 credits, no more than 3 credits may be in Independent Study (ChE 705 or Chem 705).

6 credits from 600- or 700-level courses in chemical engineering or chemistry

12 credits from any 600- or 700-level course

Qualifying Examination—A qualifying exam must be taken within three semesters of admission to the program, and passed within two years. The examination is offered every January and June. A student will only be allowed two attempts to pass the examination.

Formation of Thesis Committee—Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor (not thesis or dissertation advisor) in chemical engineering. As a minimum, the committee must consist of the doctoral student's advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal—Within six months of forming the dissertation committee, doctoral students must make an oral presentation to their committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months (i.e. doctoral students must have an approved dissertation committee, and an approved dissertation proposal, within a year of passing the qualifying examination).

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final formal approval to be granted.

If students are unable to complete the requirements for the degree, they may become a candidate for the Master of Science in Chemical Engineering upon completion of requirements for that degree.

■ DEGREE OF ENGINEER

This program is for the practicing professional chemical engineer. It emphasizes the application of new scientific knowledge to the engineer's practice.

Admission Requirements

A master's degree in chemical engineering; and at least three years of professional experience as a chemical engineer. A GPA of at least 3.0 in previous graduate studies is also required for admission.

Degree Requirements

Students accepted as candidates for the Degree of Engineer must complete a total of 36 credits, including 24 credits of course work and a 12-credit professional design project.

Chemistry

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Associate Chairpersons: Carol Venanzi (chemistry), Reginald Tomkins (undergraduate programs), Richard Trattner (environmental science)
Sponsored Chair: Kamalesh Sirkar (membrane separations and biotechnology)
Director of Freshman Chemistry: Conley
Chemistry Division
Distinguished Professors: Bozzelli, Venanzi
Professors: Gund, Kebbekus, Kimmel, Kristol, Perlmutter, Trattner, Tomkins
Associate Professors: Dauerman, Getzin, Grow, Krasnoperov, Lambert, Lei, Mitra
Assistant Professor: Cagnati
Graduate Advisor: Carol Venanzi (201) 596-3596

Degrees Offered: Master of Science in Applied Chemistry; Doctor of Philosophy in Chemistry offered by Rutgers-Newark

■ MASTER OF SCIENCE IN APPLIED CHEMISTRY

A flexible program intended for students qualified to conduct advanced study in chemistry.

Admission Requirements

Normally an undergraduate degree in chemistry or chemical engineering is required. Students with baccalaureate degrees in other areas of science and engineering may be required by the department to take an individually designed program of courses (that may include undergraduate courses) before beginning their graduate curriculum. These courses are not counted toward degree credit.

A minimum undergraduate grade point average (GPA) of 3.0 on a 4.0 scale, or equivalent, is normally required for admission. Graduate

Record Examinations (GRE) scores must be submitted. International students must also submit scores in the Test of English as a Foreign Language (TOEFL). International students applying for financial support must achieve a minimum TOEFL score of 550.

Degree Requirements

A minimum of 30 degree credits is required. Students must attain a cumulative GPA of 3.0 or better in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in ChE 791 Graduate Seminar, which does not count toward degree credits.

CORE COURSES

3 credits from:
Chem 502 Advanced Organic Chemistry I
Chem 602 Advanced Organic Chemistry II
3 credits from:
Chem 661 Instrumental Analysis
Chem 664 Advanced Analytical Chemistry
6 credits:
Chem 610 Advanced Inorganic Chemistry
Chem 658 Advanced Physical Chemistry

THESIS

Required of those receiving departmental or research-based support; others may choose a minimum of 6 credits of 600- or 700-level courses in chemical engineering or chemistry instead of thesis.
6 credits: Chem 701 Master's Thesis

ELECTIVE

6 to 12 credits from 600- or 700-level courses in chemistry or chemical engineering

3 credits from 600- or 700-level courses. May be from outside chemistry or chemical engineering.

3 credits from 500- or 600-level courses. May be from outside chemistry or chemical engineering.

■ DOCTOR OF PHILOSOPHY IN CHEMISTRY

This program is offered by Rutgers-Newark with NJIT cooperation. NJIT faculty, holding joint appointments at both NJIT and Rutgers-Newark, supervise doctoral students each year. Admission is handled by Rutgers-Newark. The degree is conferred by Rutgers, The State University of New Jersey. For program description, contact the guidance advisor or consult the Newark College of Arts and Sciences Graduate Catalog.

Civil Engineering

Administered by: Department of Civil and Environmental Engineering

Chairperson: William R. Spillers
Associate Chairperson: Edward G. Dauenheimer
Distinguished Professors: F. Liskowitz, Pignataro, Spillers
Professors: F. Ansari, Bagheri, Chan, Cheng, Dauenheimer, Deutschman, Dresnack, Golub, Hsieh, Hsu, Khera, Konon, Raghu, Salek, Schuring, Wecharatana
Associate Professors: Greenfeld, Meegoda, Olenik, Saadeghvaziri
Assistant Professors: Axe, Marhaba, Mouskos
Administrative Coordinator: Roberta Hartlaub

Graduate Advisor: Edward G. Dauenheimer (201) 596-2443, e-mail dauenheimer@admin.njit.edu

Degrees Offered: Master of Science in Civil Engineering; Degree of Engineer; Doctor of Philosophy in Civil Engineering

With the end of the cold war, more resources are available for building new cities, repairing the infrastructure, cleaning up the environment: These are all tasks for the civil engineer. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ civil engineers.

In-depth knowledge in one of the areas of civil engineering is essential for professional practice as well as for research. The M.S. in Civil Engineering is designed for those who want both specialized training and the flexibility to tailor their program to their needs. Courses are taught by full-time faculty members with a range of academic and professional experience as well as by adjunct instructors who are experts in their fields. Those students interested in research or continuing their education at the Ph.D. level should consider working with faculty involved in one of the related research centers.

■ MASTER OF SCIENCE IN CIVIL ENGINEERING

Admission Requirements

Applicants are expected to have an undergraduate degree in civil engineering or its equivalent, and will be asked to demonstrate proficiency in basic sciences and mathematics. Students who lack an appropriate undergraduate background may be granted conditional admission in order to complete the following bridge program or its equivalent. These courses are taken in addition to regular degree requirements; descriptions may be found in the undergraduate catalog.

Bridge Program—Students who do not have a bachelor's degree in civil engineering, but who want to obtain a master's degree in civil engineering must complete a bridge program for their chosen area of specialization. These courses are not counted for degree credit. See below under Areas of Specialization for specific bridge programs. Please note that prerequisites for bridge courses also must be met.

Graduate Certificate Program—12-credit graduate certificates in Construction Management or in Geographic Information System and Environmental Problems are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

The program as shown below offers numerous areas of specialization, each with its own list of required and elective courses and its own bridge program. Once the choice of specialization is made, the student consults his/her specialization advisor to plan and develop an individualized and cohesive sequence of courses that will meet program requirements of at least 30 degree credits.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in CE 791 Graduate Seminar.

AREAS OF SPECIALIZATION

Construction/Facilities Engineering and Management

Bridge Program:
CE 200 Surveying
CE 200A Surveying Laboratory
CE 210 Construction Materials and Procedures
CE 341 Soil Mechanics
CE 341A Soil Mechanics Laboratory
CIS 101 Computer Programming and Problem Solving (or equivalent)
Math 105 Elementary Probability and Statistics
Math 112 Calculus II
Mech 237 Strength of Materials
Mech 237A Strength of Materials Laboratory
one design course, approved by program advisor

REQUIRED
12 credits from:
CE 610 Construction Management
CE 611 Project Planning and Control
CE 616 Construction Cost Estimating
EM 632 Legal Aspects in Construction

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
9 or 15 credits from:
CE 545 Rock Mechanics I
CE 553 Design and Construction of Asphalt Pavements
CE 614 Underground Construction
CE 615 Infrastructure and Facilities Remediation
CE 631 Advanced Reinforced Concrete Design
CE 637 Short Span Bridge Design
CE 642 Foundation Engineering
CE 659 Flexible and Rigid Pavements
CE 700 Civil Engineering Projects
CE 702 Special Topics in Civil and Environmental Engineering
CE 710 Systems in Building Construction
CE 711 Methods Improvement in Construction
Arch 647 Special Topics in Computer Applications
Arch 662 Infrastructure Planning
EM 602 Management Science
EM 655 Management Aspects of Information Systems
EM 660 Financing an Industrial Enterprise
EM 693 Managerial Economics
EnE 662 Site Remediation
EnE 671 Environmental Impact Analysis
HRM 693 Employment Relationships and the Law
IE 603 Behavior Science in Engineering Organizations
3 credits from:
Math 611 Numberical Methods for Computation
MIS 545 Management Information Systems
Other suitable electives may be taken subject to approval of program advisor.

Environmental Engineering

Bridge Program:
CE 320 Fluid Mechanics
CE 321 Water Resources Engineering
CE 322 Hydraulic Engineering
CE 501 Introduction to Soil Behavior
Chem 126 General Chemistry II
CIS 101 Computer Programming and Problem Solving
Math 222 Differential Equations
Mech 234 Engineering Mechanics
Mech 236 Dynamics

REQUIRED
6 credits from:
EnE 560 Chemistry for Environmental Engineers
EnE 661 Microbiology for Environmental Engineers

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
15 to 21 credits from:
CE 602 Geographic Information System
CE 604 Environmental Modeling in Remote Sensing
CE 618 Applied Hydrogeology
CE 620 Open Channel Flow
CE 621 Hydrology
CE 623 Groundwater Hydrology
CE 647 Geotechnical Aspects of Solid Waste
CE 648 Flow Through Soils
CE 700 Civil Engineering Projects
CE 702 Special Topics in Civil and Environmental Engineering
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 662 Site Remediation
EnE 664 Physical and Chemical Treatment
EnE 665 Biological Treatment
EnE 666 Analysis of Receiving Waters
EnE 667 Solid Waste Disposal Systems
EnE 668 Air Pollution Control
EnE 669 Water and Wastewater Analysis
EnE 670 Advanced Processes in Water Pollution Control
EnE 671 Environmental Impact Analysis
Up to 6 credits may be selected from departments other than civil and environmental engineering subject to approval of program advisor.

3 credits from:
Math 611 Numerical Methods for Computation
Math 661 Applied Statistics
Math 687 Quantitative Analysis for Environmental Design Research
Other suitable electives may be taken subject to approval of program advisor.

Geoenvironmental Engineering

Bridge Program:
CE 320 Fluid Mechanics
CE 321 Water Resources Engineering
CE 501 Introduction to Soil Behavior
Chem 126 General Chemistry II
CIS 101 Computer Programming and Problem Solving
Math 222 Differential Equations

REQUIRED
12 credits from:
CE 618 Applied Hydrogeology
CE 647 Geotechnical Aspects of Solid Waste
EnE 560 Chemistry for Environmental Engineers
EnE 662 Site Remediation

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
15 credits from:
CE 545 Rock Mechanics I
CE 602 Geographic Information System (GIS)
CE 621 Hydrology
CE 623 Groundwater Hydrology
CE 641 Engineering Properties of Soils
CE 642 Foundation Engineering
CE 643 Advanced Foundation Engineering
CE 644 Geology in Engineering
CE 646 Geosynthetics and Soil Improvement
{ CE 700 Civil Engineering Project *or*
{ CE 702 Special Topics in Civil and Environmental Engineering
CE 743 Contaminant Transport in Soils
EM 631 Legal Aspects in Environmental Engineering
EM 633 Legal Aspects of Health and Safety
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 661 Microbiology for Environmental Engineers
EnE 664 Physical and Chemical Treatment

EnE 665 Biological Treatment
EnE 667 Solid Waste Disposal Systems
EnE 669 Water and Wastewater Analysis
EnE 671 Environmental Impact Analysis
Other suitable electives may be taken subject to approval of program advisor.

3 credits from:
Math 611 Numerical Methods for Computations
Math 651 Applied Mathematics I
Math 661 Applied Statistics
Math 687 Quantitative Analysis for Environmental Design Research

Geotechnical Engineering

Bridge Program:
CE 320 Fluid Mechanics
CE 332 Structural Analysis
CE 334 Introduction to Structural Design
CE 341 Soil Mechanics
CE 341A Soil Mechanics Laboratory
CE 443 Foundation Design
CIS 101 Computer Programming and Problem Solving
Math 222 Differential Equations

REQUIRED
6 credits from:
CE 641 Engineering Properties of Soils
CE 642 Foundation Engineering

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
12 to 18 credits from:
CE 545 Rock Mechanics I
CE 643 Advanced Foundation Engineering
CE 644 Geology in Engineering
CE 645 Rock Mechanics II
CE 646 Geosynthetics and Soil Improvement
CE 647 Geotechnical Aspects of Solid Waste
CE 648 Flow Through Soils
CE 700 Civil Engineering Projects
CE 740 Earth Supporting Structures
CE 741 Theoretical Soil Mechanics
CE 742 Geotechnology of Earthquake Engineering
CE 743 Contaminant Transport in Soils
3 to 6 credits from:
CE 553 Design and Construction of Asphalt Pavements
CE 610 Construction Management
CE 611 Project Planning and Control
CE 614 Underground Construction
CE 630 Advanced Structural and Matrix Analyses
CE 631 Advanced Reinforced Concrete Design
CE 659 Flexible and Rigid Pavements
Mech 630 Theory of Elasticity
3 credits from:
Math 611 Numerical Methods for Computations
Math 651 Applied Mathematics I
Math 661 Applied Statistics

Structural Engineering

Bridge Program:
CE 332 Structural Analysis
CE 334 Introduction to Structural Design
CE 341 Soil Mechanics
CE 341A Soil Mechanics Laboratory
CE 434 Structural Design
CIS 101 Computer Programming and Problem Solving
Math 222 Differential Equations
Mech 237 Strength of Materials
Mech 237A Strength of Materials Laboratory

REQUIRED
3 credits:
CE 630 Matrix Analysis of Structures

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
18 or 24 credits from:
CE 530 Applied Finite Element Method
CE 531 Design of Masonry and Timber Structures
CE 545 Rock Mechanics I
CE 631 Advanced Reinforced Concrete Design
CE 632 Prestressed Concrete Design
CE 634 Structural Dynamics
CE 635 Fracture Mechanics of Engineering Materials
CE 636 Stability of Structures
CE 637 Short Span Bridge Design
CE 638 Nondestructive Testing Methods in Civil Engineering
CE 641 Engineering Properties of Soils
CE 642 Foundation Engineering
CE 661 Analysis and Design of Shell Structures
CE 700 Civil Engineering Project
CE 702 Special Topics in Civil and Environmental Engineering
CE 730 Plastic Analysis and Design
CE 733 Design of Metal Structures
CE 734 Design of Tall Buildings and Space Structures
CE 736 Finite Element Methods in Structural and Continuum Mechanics
CE 737 Earthquake Engineering
CE 738 Advanced Matrix Analysis of Structures
CE 739 Structural Optimization
Mech 540 Advanced Strength of Materials
Mech 630 Theory of Elasticity
Other suitable electives may be taken subject to approval of program advisor.
3 credits from:
Math 611 Numerical Methods for Computation
Math 630 Linear Algebra and Applications
Math 651 Applied Mathematics I
Mgmt 580 Managerial Science

Urban and Transportation Engineering

REQUIRED
12 credits from:
CE 650 Urban Systems Engineering
CE 655 Land Use Planning
CE 660 Traffic Studies and Capacity
Math 661 Applied Statistics

THESIS
Required of those receiving departmental awards; elective for all others
6 credits: CE 701 Master's Thesis

ELECTIVE
9 to 15 credits from:
CE 552 Geometric Design of Transportation Facilities
CE 553 Design and Construction of Asphalt Pavements
CE 603 Introduction to Urban Transportation Planning
CE 625 Public Transportation Operations and Technology
CE 653 Traffic Safety
CE 659 Flexible and Rigid Pavements
CE 700 Civil Engineering Project
CE 705 Mass Transportation Systems
CE 751 Transportation Design
CE 752 Traffic Control
CE 753 Airport Design and Planning
CE 754 Port Design and Planning
CE 765 Multi-Model Freight Transportation Systems Analysis
Tran 604 Economic Analysis of Urban Areas
Tran 610 Transportation Economics
Tran 643 Transportation Finance
3 credits from:
CE 602 Geographic Information System
EnE 671 Environmental Impact Analysis
SSPS 521 Urban Social Structure
Other suitable electives may be taken subject to approval of program advisor.

■ DOCTOR OF PHILOSOPHY IN CIVIL ENGINEERING

This is a program for superior students with master's degrees in civil engineering or allied fields who wish to do advanced research in an area of civil engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in civil engineering may be accepted directly into the doctoral program.

Admission Requirements

Applicants are expected to have superior academic backgrounds in civil engineering. A minimum GRE score of 1600 is expected.

Degree Requirements

Candidates must conduct independent original research in a specific area of civil engineering. Degree requirements and dissertation topics are approved by the department on an individual basis.

Within one year after being accepted into the doctoral program, candidates must pass a qualifying examination administered by the department. Candidates must select an advisor to supervise his/her dissertation work and form an advisory committee immediately after passing the preliminary qualifying examination. Additional information can be found in this catalog under the heading "Academic Policies and Procedures" and from the "Requirements for Doctorate," published by the department.

Seminar— CE 791 Graduate Seminar is required of all doctoral students each semester.

■ DEGREE OF ENGINEER

This program is for the practicing professional civil engineer. It emphasizes the application of new scientific knowledge to the engineer's practice.

Admission Requirements

A master's degree in civil engineering; and at least three years of professional experience as a civil engineer. A GPA of at least 3.0 in previous graduate studies is also required for admission.

Degree Requirements

Students accepted as candidates for the Degree of Engineer must complete a total of 36 credits, including 24 credits of course work and a 12-credit professional design project. Additional information can be found in this catalog under the heading "Academic Policies and Procedures."

Computer Engineering

Administered by: Department of Electrical and Computer Engineering

Chairperson: Richard Haddad
Associate Chairpersons: Kenneth Sohn, Gerald Whitman (graduate)
Director of Computer Engineering: Jacob Savir
Professors: Rosenstark, Savir
Associate Professors: Carpinelli*, Hou, Manikopoulos, Shih*, Stoyenko*, Zhou, Ziavras
Assistant Professors: Eshaghian*, Karvelas*

*Joint appointee with the Department of Computer and Information Science

Graduate Advisor: Jacob Savir (201) 596-5681, e-mail savir@admin.njit.edu

Degree Offered: Master of Science in Computer Engineering

■ MASTER OF SCIENCE IN COMPUTER ENGINEERING

This program prepares its graduates to successfully handle problems requiring in-depth knowledge of both computer hardware and software, and more important, their interaction. Students may concentrate in microprocessor-based systems, parallel computing systems, computer networking, VLSI system design, or machine vision systems.

Admission Requirements

Students are expected to have an undergraduate education in engineering or computer science. Students with baccalaureate degrees in areas other than computer engineering will be required to complete a bridge program. Those with undergraduate degrees in other fields should consult the Director of Computer Engineering for bridge requirements. Bridge courses do not count toward degree requirements.

Bridge Program—Students with undergraduate degrees in computer science take a maximum of 9 credits from:

CIS 453 Microcomputers and Applications *or*
CoE 393 Assembly Language Lab
CoE 353 Advanced Computer Architecture *or*
EE 487 Computer Systems
EE 231 Circuits and Systems I

Students with undergraduate degrees in electrical engineering take a maximum of 9 credits from:

CIS 105 Computer Programming (C)
CIS 335 Data Structures and Algorithm Design
EE 487 Computer Systems Elective
EE 497 Computer Systems Laboratory

Degree Requirements

Students must complete 30 credits, including the two-course sequence in at least one of the five areas of concentration. Students in all areas must take the two required core courses indicated below and complete either a master's project or thesis. As a requirement for graduation, students must achieve a 3.0 cumulative GPA, not including the master's thesis or project. The master's thesis or project grade must be B or higher.

Seminar—In addition to the minimum 30 degree credits required, all students receiving departmental or research-based support must enroll each semester in CoE 791 Graduate Seminar or EE 791 Graduate Seminar.

CORE

Required for all specializations
6 credits:
CoE 651 Computer Systems Architecture
CIS 610 Data Structures and Algorithms

PROJECT OR THESIS (required)
3 credits: CoE 700 Master's Project *or*
6 credits: CoE 701 Master's Thesis

ELECTIVE

15 to 18 credits:
A list of suggested complementary elective courses is available for each area of concentration. Consult the Director of Computer Engineering for a current list of these courses. Other courses may be used as electives with the permission of the Director of Computer Engineering.

AREAS OF SPECIALIZATION

Microprocessor-Based Systems

REQUIRED
6 credits:
EE 686 Instrumentation Systems and Microprocessors
EE 688 Microcontrollers in Instrumentation

Parallel Computing Systems

REQUIRED
6 credits:
EE 689 Digital System Design for Machine Arithmetic
EE 785 Parallel Processing Systems

Computer Networking

REQUIRED
6 credits:
CIS 656 Internetworking and Higher Layer Protocols
EE 683 Computer Network Design and Analysis

VLSI System Design

REQUIRED
6 credits:
EE 658 VLSI Design I
EE 758 VLSI Design II

Machine Vision Systems

REQUIRED
6 credits:
CIS 659 Image Processing and Analysis *and*
CIS 780 Computer Vision
or
EE 601 Linear Systems *and*
EE 643 Digital Image Processing I

Computer Science

Administered by: Department of Computer and Information Science

Chairperson: Peter A. Ng
Associate Chairpersons: D.C. (Douglas) Hung, James A.M. McHugh, Julian M. Scher
Assistant Chairperson: Fadi Deek (undergraduate)
Distinguished Professors: Hiltz, Turoff
Distinguished Research Professors: Neuhold, R.T. Yeh
Professors: McHugh, Ng, Perl, Verkhovsky
Associate Professors: Baltrush, Carpinelli*, Featheringham, Geller, Hung, Manikopoulos*, Nassimi, Ryon, Sarian, Scher, Shih*, Stoyenko*, Tanik, J. Wang, Ziavras*
Assistant Professors: Baruah, Bieber, Calvin, Eshaghian*, Hinchey, Hua, Karvelas*, Kravets, Rana, Rossak, Scherl, Silberman, Sohn, Suresh, Suri, Welch, Yener
Professional/Instructional Staff: Deek, Jololian

Graduate Advisors: Peter Ng; Murray Turoff (management doctorate); James A.M. McHugh (computer science doctorate and master's) (201) 596-3366

*Joint appointee with the Department of Electrical and Computer Engineering

Degrees Offered: Master of Science in Biomedical Informatics offered jointly with the School of Health Related Professions, UMDNJ; Master of Science in Computer Science; Master of Science in Information Systems; Master of Science in Telecommunications offered jointly with the Department of Electrical and Computer Engineering (pending approval); Doctor of Philosophy in Biomedical Informatics offered jointly with the School of Health Related Professions, UMDNJ (pending approval); Doctor of Philosophy in Computer Science

The Department of Computer and Information Science is distinguished by prominent researchers who are actively investigating new applications in real-time computing, parallel processing and advanced computer architecture, systems integration, and information processing and retrieval.

A dozen research teams are working to meet current industry, government and corporate computer and information needs in these areas as well as in artifical intelligence, computer communications and networking, multimedia, hypermedia information systems, computer vision, data and knowledge communications, and software engineering. Departmental research is conducted through the Institute for Integrated Systems Research.

The department strives to provide an environment that gives students the background and skills necessary for entry into today's workplace. This is achieved through team research in state-of-the-art facilities; a faculty that works steadily in the forefront of many research areas; interaction with industry and experts; and an administration focused on research and student services. As a result, the department attracts the largest student population for computer and information science in the greater New York/New Jersey area.

In addition to the university's extensive networked computing resources, including a VAX 6430, VAX 8800, DEC 550 and MASPAR machine, the department maintains its own machines, which are

housed in the Guttenberg Information Technologies Building. Among them are an N-CUBE, Microvax cluster, Sun file server (Sparc file servers 20, 4/690, 4/670, 2000s and others), Sparc workstations, and five 486-based AT&T star server S machines. A PC multimedia lab equipped with 20 90-MHz Pentiums also is available.

■ MASTER OF SCIENCE IN COMPUTER SCIENCE

Recognizing that a variety of academic backgrounds may be suited to this discipline, this program is for all students who want advanced studies in computer science.

Off-Campus Programs—At the TEC branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described below) to qualified students who have access to a VCR and personal computer with modem. In addition, distance-based, 12-credit graduate certificates in Object-Oriented Design, Programming Environment Tools, or Telecommunications Networking are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs, ACCESS/NJIT programs, and graduate certificates, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail:cpe@njit.edu

Admission Requirements

Applicants are expected to have backgrounds in computer science and mathematics equivalent to the bridge program courses listed below. Students who lack this background must take these bridge courses and are expected to attain a cumulative GPA of 3.0. At the discretion of the department, students who have completed courses equivalent to the bridge program may be granted a corresponding reduction in the bridge requirements. See the undergraduate catalog for descriptions of 100- to 300-level courses. These courses are not counted toward degree requirements.

Bridge Program:
CIS 251 Computer Organization
CIS 332 Principles of Operating Systems
CIS 333 UNIX Operating System
CIS 505 Programming, Data Structures, and Algorithms
CIS 510 Assembly Language Programming and Principles
Math 111 Calculus I
Math 112 Calculus II
Math 211 Calculus III
Math 226 Discrete Analysis
Math 333 Probability and Statistics

Off-Campus Programs—At the TEC branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described below) to qualified students who have access to a VCR and personal computer with a modem. In addition, distance-based, 12-credit graduate certificates in Object-Oriented Design, in Programming Environment Tools or in Telecommunications Networking are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060.

Degree Requirements

Degree candidates are assigned an advisor to assist them in formulating a program of study and in selecting an area of specialization. A minimum of 30 credits must be taken, including a set of core courses, a thesis or project, and required and elective courses.

The systems integration area of specialization described below is multidisciplinary. It focuses on the computer services and manufacturing industries. This specialization requires a minimum of 36 degree credits.

With the approval of the graduate advisor, students may take 700-level courses in computer science, or courses outside the department as electives.

Seminar—In addition, all students must attend a non-credit seminar in conjunction with their thesis or project. Those students who receive departmental or research-based support must enroll each semester in CIS 710 Computer Science Seminar.

CORE

9 credits for all specializations:
CIS 610 Data Structures and Algorithms
CIS 635 Computer Programming Languages
CIS 650 Computer Architecture

REQUIRED *(for all specializations except Systems Integration)*
3 credits from:
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 636 Compiling System Design
CIS 651 Data Communications
CIS 673 Software Design and Production Methodology

PROJECT OR THESIS (required)
3 to 6 credits:
CIS 700 Master's Project *or*
CIS 701 Master's Thesis

AREAS OF SPECIALIZATION

The student may take a modified area of specialization with the approval of the graduate advisor.

Artificial Intelligence

ELECTIVE
12 to 15 credits from:
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 665 Algorithmic Graph Theory
CIS 667 Design Techniques for Algorithms
CIS 670 Artificial Intelligence
CIS 671 Knowledge-Based Systems
CIS 672 Expert System Methods and Design
CIS 674 Natural Language Processing
CIS 780 Computer Vision
Other 600/700-level courses as approved by graduate advisor.

Computer Algorithms and Theory of Computing

ELECTIVE
12 to 15 credits from:
CIS 540 Fundamentals of Logic and Automata
CIS 605 Discrete Event Dynamic Systems
CIS 611 Introduction to Computability and Complexity
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 640 Recursive Function Theory
CIS 641 Formal Languages and Automata
CIS 665 Algorithmic Graph Theory
CIS 667 Design Techniques for Algorithms
CIS 668 Parallel Algorithms
CIS 669 Computational Geometry
Other 600/700-level courses as approved by graduate advisor.

Computer Communications and Networking

ELECTIVE
12 to 15 credits from:
CIS 604 Client/Server Computing
CIS 630 Operating System Design
CIS 651 Data Communications
CIS 652 Computer Networks-Architectures, Protocols and Standards
CIS 654 Telecommunication Networks Performance Analysis
CIS 656 Internetworking and Higher Layer Protocols
CIS 735 Computer Mediated Communication Systems
CIS 741 Communication Network Design
Other 600/700-level courses as approved by graduate advisor.

Computer and Information Systems Management

ELECTIVE
12 to 15 credits from:
CIS 603 Advanced Programming Environments and Tools
CIS 631 Data Management System Design
CIS 651 Data Communications
CIS 652 Computer Networks-Architectures, Protocols and Standards
CIS 658 Multimedia Systems
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 673 Software Design and Production Methodology
CIS 675 Information System Evaluation
CIS 676 Requirements Engineering
CIS 677 Information System Principles
CIS 679 Management of Computer and Information Systems
CIS 684 Business Process Innovation
CIS 688 Programming for Interactive Environments
CIS 732 Design of Interactive Systems
Other 600/700-level courses as approved by graduate advisor.

Computer Systems, and Parallel and Distributed Processing

ELECTIVE
12 to 15 credits from:
CIS 630 Operating System Design
CIS 633 Distributed Systems
CIS 636 Compiling System Design
CIS 637 Real-Time Systems
CIS 651 Data Communications
CIS 653 Microcomputers and Applications
CIS 654 Telecommunication Networks Performance Analysis
CIS 656 Internetworking and Higher Layer Protocols
CIS 665 Algorithmic Graph Theory
CIS 668 Parallel Algorithms
CIS 750 Parallel Processing: Architectures and Programming
EE 658 VLSI Design I
EE 758 VLSI Design II
EE 689 Digital System Design for Machine Arithmetic
EE 784 Digital Systems Architecture
Other 600/700-level courses as approved by graduate advisor.

Database and Knowledge-Based Engineering

ELECTIVE
12 to 15 credits from:
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 632 Advanced Database System Design
CIS 651 Data Communications
CIS 658 Multimedia Systems
CIS 670 Artificial Intelligence
CIS 671 Knowledge-Base Systems
CIS 672 Expert System Methods and Design
Other 600/700-level courses as approved by graduate advisor.

Graphics and Image Processing

ELECTIVE
12 to 15 credits from:
CIS 630 Operating System Design
CIS 632 Advanced Database System Design
CIS 657 Principles of Interactive Computer Graphics
CIS 659 Image Processing and Analysis
CIS 665 Algorithmic Graph Theory
CIS 667 Design Techniques for Algorithms
CIS 682 Geometric Modeling
CIS 759 Advanced Image Processing and Analysis
CIS 780 Computer Vision
EE 601 Linear Systems
EE 643 Digital Image Processing I
ME 635 Computer-Aided Design
Other 600/700-level courses as approved by graduate advisor.

Numerical Computation

ELECTIVE
12 to 15 credits from:
CIS 621 Numerical Analysis I
CIS 622 Numerical Analysis II
CIS 657 Principles of Interactive Computer Graphics
CIS 667 Design Techniques for Algorithms
Math 674 Boundary Value Problems
Math 675 Partial Differential Equations
Math 676 Advanced Ordinary Differential Equations
Other 600/700-level courses as approved by graduate advisor.

Software Engineering

ELECTIVE
12 to 15 credits from:
CIS 601 Object-Oriented Programming in C++
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 636 Compiling System Design
CIS 657 Principles of Interactive Computer Graphics
CIS 667 Design Techniques for Algorithms
CIS 670 Artificial Intelligence
CIS 673 Software Design and Production Methodology
CIS 676 Requirements Engineering
CIS 683 Object-Oriented Software Development
CIS 688 Programming for Interactive Environments
Other 600/700-level courses as approved by graduate advisor.

Systems Analysis, Simulation and Modeling

ELECTIVE
12 to 15 credits from:
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 660 Systems Analysis Methodology *(pending)*
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 673 Software Design and Production Methodology
CIS 675 Information System Evaluation
Other 600/700-level courses as approved by graduate advisor.

Systems Integration

CORE
9 credits:
CIS 610 Data Structures and Algorithms
CIS 635 Computer Programming Languages
CIS 650 Computer Architecture

REQUIRED
12 credits:
CIS 630 Operating System Design
CIS 631 Data Management System Design
CIS 651 Data Communications
EM 636 Project Management

PROJECT OR THESIS (required)
3 to 6 credits:
CIS 700 Master's Project *or*
CIS 701 Master's Thesis

ELECTIVE
12 credits in the areas of process characterization, re-engineering and simplification of processes, converging to a common system architecture, and automation of processes and systems. The following lists of electives are merely suggestions. Students should consult with their advisor to select appropriate electives.

12 credits:
MnE 601 Manufacturing Systems
MnE 602 Manufacturing Systems Integration
MnE 603 Management of Manufacturing Systems
IE 612 Robotic Manufacturing Systems

12 credits:
IE 616 Planning and Control of Products and Processes
IE 618 Operations Cost Planning and Control
IE 644 Applications of Stochastic Modeling in Systems Control
IE 673 Total Quality Management

12 credits:
EE 686 Instrumentation Systems and Microprocessors
EE 688 Microcontrollers in Instrumentation
MnE 602 Manufacturing Systems Integration
IE 616 Planning and Control of Products and Processes

■ MASTER OF SCIENCE IN INFORMATION SYSTEMS

The master's program in Information Systems emphasizes the organizational context of software development, information systems analysis and design, functional requirements specification, application systems design, and software engineering methodology.

Admission Requirements

Applicants are expected to have backgrounds in computer science and mathematics equivalent to the bridge program courses listed below. In addition, students must demonstrate an undergraduate background in economics, psychology or sociology, and organizational theory. Students who lack this background must take these bridge courses and are expected to attain a cumulative GPA of 3.0 in them. At the discretion of the department, students who have completed courses equivalent to the bridge program, may be granted a corresponding reduction in the bridge requirements. See the undergraduate catalog for descriptions of 100- to 300-level courses. These courses are not counted toward degree requirements.

Bridge Program:
Acct 515 Accounting for Managerial Control
CIS 251 Computer Organization
CIS 332 Principles of Operating Systems
CIS 431 Database System Design and Management
CIS 451 Data Communications
CIS 505 Programming, Data Structures, and Algorithms
Econ 565 Managerial Economics
Fin 516 Principles of Financial Management
Math 111 Calculus I
Math 112 Calculus II
Math 211 Calculus III
Math 333 Probability and Statistics
Math 334 Mathematics for Management Science
Mrkt 530 Principles of Marketing

Off-Campus Programs—At the TEC branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described below) to qualified students who have access to a VCR and personal computer with a modem. In addition, distance-based, 12-credit graduate certificates in Object-Oriented Design, in Programming Environment Tools or in Telecommunications Networking are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

The program consists of 36 credits, including 18 credits in an area of specialization, 15 credits of required courses and a 3-credit project of designing, developing and evaluating a prototype information system.

Seminar—In addition to the minimum 36 degree credits required, all students who receive departmental or research-based awards must enroll each semester in CIS 710 Computer Science Seminar.

REQUIRED
15 credits:
CIS 635 Computer Programming Languages
CIS 673 Software Design and Production Methodology
CIS 675 Information System Evaluation *or*
CIS 677 Information Systems Principles
Fin 624 Financial Management *or*
HRM 601 Organizational Behavior
Mgmt 691 Legal and Ethical Issues *or*
Mrkt 632 Marketing Strategy for Technology-Based Organizations

PROJECT (required)
3 credits: CIS 700 Master's Project

AREAS OF SPECIALIZATION

A total of 18 credits are required in at least three specialty areas: two areas must be selected in computer and information science and one area must be chosen from a non-CIS application.

Computer and Information Science

12 credits:
Choose any two areas and any two courses within each area.

DATABASE
CIS 631 Data Management System Design
CIS 632 Advanced Database System Design
CIS 634 Information Retrieval

DATA COMMUNICATIONS
CIS 651 Data Communications
CIS 652 Computer Networks-Architectures, Protocols and Standards
CIS 656 Internetworking and Higher Layer Protocols

EXPERT SYSTEMS
CIS 670 Artificial Intelligence
CIS 671 Knowledge-Based Systems
CIS 672 Expert Systems Methods and Design

GRAPHICAL USER INTERFACES AND SOFTWARE DEVELOPMENT
CIS 601 Object-Oriented Programming in C++
CIS 603 Advanced Programming Environments and Tools
CIS 657 Principles of Interactive Computer Graphics
CIS 658 Multimedia Systems
CIS 676 Requirements Engineering
CIS 683 Object-Oriented Software Development

INFORMATION SYSTEMS DESIGN
CIS 675 Information Systems Evaluation
CIS 679 Management of Computer and Information Systems
CIS 684 Business Process Innovation
CIS 732 Design of Interactive Systems
CIS 735 Computer Mediated Communications Systems
CIS 754 Measurement and Evaluation of Software Quality and Performance

SIMULATION, MODELING, AND DECISION SUPPORT SYSTEMS
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 762 Computerized Information Systems for Planning and Forecasting
CIS 767 Computer-Based Decision Systems
MIS 648 Decision Support Systems

Areas of Application

6 credits:
In consultation with the graduate advisor, select two courses within one of the areas. These courses must be at the 600 level or higher. Suggested course topics are listed under each area.

INDUSTRIAL MANAGEMENT
Financial Management
Management and Operational Auditing
Marketing Management
Information Systems Management
Operations Management
Human Resources Management
Transportation Management

INDUSTRIAL AND MANUFACTURING ENGINEERING
Computer Integrated Manufacturing
Human Design Factors
Robotics
Engineering Project Management
Cost Analysis and Cost Control
Operations Research

PROFESSIONAL AND TECHNICAL COMMUNICATION
Writing
Editing
Communication

■ DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE

The degree is intended for the superior student in computer science or a related field who has an interest in and commitment to scholarly research.

Admission Requirements

Applicants are expected to have a superior background in mathematics, computer science theory and practice, and the basic sciences. They must have a bachelor's degree from an accredited institution and a demonstrated proficiency in English. Students who do not meet these requirements must strengthen their background before becoming eligible for admission. The GRE is required for applicants to this program.

Degree Requirements

Students must complete all required courses, spend one academic year in full-time residency, teach at least one computer science course under the supervision of a faculty member, and submit an acceptable final draft of the dissertation with a successful dissertation defense.

REQUIRED
24 credits of advanced courses beyond the master's degree or its equivalent in an area of specialization selected by the student with the approval of advisor. At least six must be at the 700-level.

Two semesters of CIS 791 Doctoral Seminar; each semester for all doctoral students and master's students who receive departmental or research-based support

6 credits of CIS 792 Pre-Doctoral Research; 24 credits of CIS 790 Doctoral Dissertation and Research

Qualifying Examination—The qualifying examination tests general academic preparation and competence in the theory and practice of computing. Students should apply for permission to take the test through the doctoral program director. Students without master's degrees in computer science are expected to complete 30 credits of course work, as specified by the doctoral program advisor, before they may apply for permission to take the qualifying examination.

If a student fails to pass any part of the qualifying examination, s/he must submit a plan to rectify deficiencies to the doctoral program committee in order to receive their permission to retake the examination. Students who do not receive permission to retake the examination, or students who fail to pass on the second attempt, will be dismissed from the program.

Predoctoral Research—Students who pass the qualifying examination are permitted to register for a maximum of 6 credits of predoctoral dissertation research, to prepare a proposal for their dissertation research. This is subject to advisor approval. The proposal must be defended before the dissertation committee before it is accepted.

Dissertation and Oral Examination—An oral defense of the dissertation is required after submitting the final document to the department for approval. Students must complete their dissertations and successfully defend it within five years of passing the qualifying examination or they will lose their status as degree seeking students. To restore status they will be required to retake and pass the qualifying examination.

AREAS OF SPECIALIZATION

In general, areas of specialization reflect faculty research and interests and are periodically reviewed by the department for timeliness. Samples of areas of specialization are:

Distributed Processing
Parallel Processing
Real-Time Computing
Computer Networks
Data Communications and Networking
System Architectures
Theory of Computing
Computer Algorithms and Computational Complexity
Computer Performance Evaluation
Programming Languages
Operating Systems
Data and Knowledge Management
Knowledge-Based Systems
System Development Technologies
Systems Integration
Collaborative Systems
Computer and Information Systems in Management
System Simulation and Modeling
Decision-Support Systems
Human-Computer Interaction
Information Processing and Retrieval
Artificial Intelligence
Expert Systems
Natural Language Processing
Neural Computation
Computer Graphics
Pattern Recognition
Image Processing/Computer Vision

■ MASTER OF SCIENCE IN BIOMEDICAL INFORMATICS

See "Biomedical Informatics" in this catalog for program description.

■ MASTER OF SCIENCE IN TELECOMMUNICATIONS

(pending approval)
See "Telecommunications" in this catalog for program description.

■ DOCTOR OF PHILOSOPHY IN BIOMEDICAL INFORMATICS (pending approval)

See "Biomedical Informatics" in this catalog for program description.

Electrical Engineering

Administered by: Department of Electrical and Computer Engineering
Chairperson: Richard A. Haddad
Associate Chairpersons: Kenneth Sohn, Gerald Whitman (graduate)
Assistant Chairperson: Nirwan Ansari (graduate)
Foundation Chair: Walter F. Kosonocky (optoelectronics and solid-state circuits)
Distinguished Professors: Bar-Ness, Friedland, Kosonocky
Professors: Carr, E. Cohen, Cornely, Grebel, Haddad, Klapper, Kuo, Meyer, S. Reisman, Rosenstark, Savir, Sohn, Strano, Thomas, Whitman
Associate Professors: Akansu, N. Ansari, Carpinelli, T. Chang, Clements, Engler, Frank, Haimovich, Hou, Hubbi, Manikopoulos, Misra, Niver, Shi, Sosnowski, Troop, Zhou, Ziavras
Assistant Professors: Ge, Siveski
Research Professor: Marcus

Graduate Advisors: Nirwan Ansari (201) 596-3670, e-mail ansarin@admin.njit.edu; Gerald Whitman (201) 596-3232, e-mail whitman@admin.njit.edu

Doctoral Coordinator: Yehesakel Bar-Ness (201) 596-3520, e-mail barness@admin.njit.edu
Degrees Offered: Master of Science in Computer Engineering; Master of Science in Electrical Engineering; Master of Science in Telecommunications offered jointly with the Department of Computer and Information Science (pending approval); Degree of Engineer; Doctor of Philosophy in Electrical Engineering

The Department of Electrical and Computer Engineering serves the community, the state and the nation by educating engineers, expanding knowledge and developing new tools for solving complex technological problems. The department's graduate program offers students with backgrounds in electrical engineering or related areas unusual opportunities to specialize in advanced phases of electrical engineering. In addition to more than 30 full-time faculty members devoted to teaching and research, students are taught by adjunct professors from industry who offer specialty courses in their area of expertise and serve on thesis committees.

The master's degree programs provide state-of-the-art training at advanced levels in areas of technical specialization, including faculty-supervised research. Students in the Ph.D. program conduct significant original research in areas of interest to department members. Furthermore, students have opportunities to conduct thesis research at industrial sites, hospitals, biomedical engineering facilities, and university centers and departments.

■ MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

A program for students with an undergraduate degree in engineering who wish either to specialize in an advanced phase of electrical engineering, or prepare for a more advanced degree.

Admission Requirements

Applicants are expected to have excellent undergraduate backgrounds in physics, mathematics (through differential equations and vector analysis), electrical networks and devices, electronics, analysis and design methods, transients, electromagnetic fields, and appropriate laboratory work in some of these areas.

Bridge Program—Students who have earned a Bachelor of Science in Engineering Technology (B.S.E.T.) degree, or who lack an appropriate background, must take the following courses, in addition to the degree requirements, to make up deficiencies. They must attain a grade of B or better in each course. At the discretion of the department, students who have taken courses equivalent to these may have their bridge program requirements reduced accordingly.

EE 232 Circuits and Systems II
EE 333 Circuits and Systems III
EE 361 Electromagnetic Fields I
EE 362 Electromagnetic Fields II
EE 372 Electronic Circuits II
EE 373 Electronic Circuits III

Graduate Record Examinations—The GRE is required for all full-time students.

Graduate Certificate Program—A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

*Degree Requirements

Upon entering the program, students select an area of specialization that is supervised by a faculty coordinator. The master's program consists of 30 credits. Each student should consult with the faculty coordinator for their area of specialization before registering for courses to make sure they are meeting department requirements. Faculty coordinators must approve any additional courses students wish counted towards their degrees. As a requirement for graduation, students must achieve a 3.0 cumulative GPA overall and in graduate-level courses not including the master's thesis or project.

PROJECT, THESIS, SEMINAR

Requirements vary based on status classification

- Students who enter the electrical engineering master's program and who receive departmental or research-based awards must complete a master's thesis.
- Full-time students must register each semester for 1/2 credits of EE 791 Graduate Seminar.
- Once a student registers for EE 701 Master's Thesis, s/he must complete a thesis in two years.
- Students who enter the program but who did not receive departmental or research-based awards, may complete a 30-credit master's program that includes either 6 credits of EE 701 Master's Thesis, 3 credits of EE 700 Master's Project, or 10 courses.
- Entering part-time students have three program options:

24 course credits and 6 credits of EE 701 Master's Thesis *or*
27 course credits and 3 credits of EE 700 Master's Project *or*
30 course credits not to include either EE 700 Master's Project *or* EE 701 Master's Thesis.

AREAS OF SPECIALIZATION

Entering full-time students must select an area of specialization during their first semester.

Entering *part-time students* must select an area of specialization by the beginning of their third semester.

Further specialization within each area is possible and encouraged. Students should contact the Associate Chairperson for Graduate Studies for guidance.

Coordinators:

Biomedical Systems: S. Reisman
Communication and Signal Processing: Y. Bar-Ness
Computer Systems: C. Manikopoulos
Control Systems: A. Meyer
Energy Conversion and Power: E. Cohen
Microwave and Lightwave Engineering: G. Whitman
Solid-State Materials, Devices and Circuits: R. Cornely

CORE

Each student is required to take 6 credits from the following list depending on area of specialization as noted:

EE 601 Linear Systems (all areas of specialization except Computer Systems)
EE 620 Electromagnetic Field Theory (Energy Conversion and Power, Microwave and Lightwave Engineering, Solid State Circuits and Devices)
EE 673 Random Signal Analysis (Biomedical Systems, Communications and Signal Processing, Computer Systems, Control Systems)
EE 684 Advanced Microprocessor Systems (Computer Systems, Energy Conversion and Power)

***500-LEVEL COURSES**

500-level courses in electrical engineering are not acceptable for credit toward a degree in electrical engineering. Only one 500 level course outside the department may be applied for credit toward a degree in electrical engineering.

REQUIRED

In addition to master's thesis and project requirements; total credit requirements as determined by status classification; and core courses—each area of specialization includes the following course requirements. Unless otherwise specified or approved, all courses must be in electrical engineering. Special topics courses and electives are chosen with the approval of the coordinator.

Biomedical Systems

BME 669 Quantitative Physiology for Engineers
EE 667 Systems Studies in Bioengineering
EE 687 Design of Medical Instrumentation

Communication and Signal Processing

Communications:
{EE 642 Communication Systems I
{EE 742 Communication Systems II
or
Digital Signal Processing:
{EE 640 Digital Signal Processing
{EE 740 Advanced Digital Signal Processing

Computer Systems

Computer Networking:
{EE 683 Computer Network Design and Analysis
{EE 783 Computer Communication Networks
or
VLSI System Design:
{EE 658 VLSI Design I
{EE 758 VLSI Design II
or
Microprocessor Systems:
{EE 686 Instrumentation Systems and Microprocessors
{EE 688 Microcontrollers in Instrumentation
or
Parallel Computing Systems:
{EE 689 Digital System Design for Machine Arithmetic
{EE 690 Computer Systems Architecture

Control Systems

EE 660 Control Systems I
EE 666 Control Systems II
EE 664 Real-Time Computer Control Systems

Energy Conversion and Power

EE 610 Power System Steady-State Analysis
EE 611 Transients in Power Systems

Microwave and Lightwave Engineering

Microwave Engineering:
{EE 622 Wave Propagation
{EE 630 Microwave Electronic Systems
{EE 632 Antenna Theory
or
Lightwave Engineering:
{EE 622 Wave Propagation
{EE 626 Optoelectronics
{EE 739 Laser Systems

Solid State Circuits and Devices

Solid State Circuits:
{EE 648 Digital Microelectronics
{EE 650 Electronic Circuits
{EE 657 Semiconductor Devices
or
Solid State Devices:
{EE 657 Semiconductor Devices
{EE 659 Fabrication Principles of Electronic and Optoelectronic Devices

■ DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING

This is a program for superior students with master's degrees in electrical engineering or allied fields who wish to do advanced research in an area of electrical engineering.

Exceptional Candidates with Bachelor of Science in Electrical Engineering

Highly qualified students with bachelor's degrees in electrical engineering may be accepted directly into the doctoral program. Contact the department for further information.

Admission Requirements

Applicants are expected to have a broad background in engineering, mathematics, physics, and computer science. At least half of undergraduate course work should have been in physical science or similar fields. At the master's level, doctoral students should have majored in electrical engineering or a related field, with course work in one or more of mathematics, physics and computer science. In addition, students are expected to be proficient in computer programming.

Students who lack an appropriate background will be required to take additional courses that cannot be applied as degree credit.

Degree Requirements

Requirements are determined in consultation with department advisors. In general, they include at least 24 credits of course work excluding department core courses and certain other basic area courses with 12 credits of 700-level courses and 36 credits of EE 790 Doctoral Dissertation and Research. See coordinator for specifics. Registration for ½ credit of EE 791 Graduate Seminar is required each semester. Dissertations should demonstrate original research that contributes to the knowledge in the field. Students must provide the department a written proposal showing that facilities are available and that there is a faculty member willing to supervise dissertation work. Students who complete 36 credits of EE 790 before research is finished, must register for a minimum of 3 credits of EE 790 each semester thereafter until the dissertation has been accepted.

Residency—Degree-seeking students must spend at least one academic year in full-time residence.

Qualifying Examination—contains material related to the student's intended area of specialization. See department for more details.

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval.

Pre-Doctoral Research—With department approval, well-qualified students may register for up to a maximum of nine credits of EE 792 Pre-Doctoral Research before completing the qualifying examination. A maximum of 6 credits of EE 792 may be applied toward EE 790.

■ DEGREE OF ENGINEER

This program is for the practicing professional electrical engineer. It emphasizes the application of new scientific knowledge to the engineer's practice.

Admission Requirements

A master's degree in electrical engineering; and at least three years of professional experience as an electrical engineer are required. A GPA of at least 3.0 in previous graduate studies is also required for admission.

Degree Requirements

Students accepted as candidates for the Degree of Engineer must complete a total of 36 credits, including 24 credits of course work and a 12-credit professional design project. A qualifying examination is also required.

■ MASTER OF SCIENCE IN COMPUTER ENGINEERING

See "Computer Engineering" in this catalog for program description.

■ MASTER OF SCIENCE IN TELECOMMUNICATIONS

(pending approval)
See "Telecommunications" in this catalog for program description.

Engineering Management

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Paul G. Ranky
Associate Chairperson: Kevin J. McDermott
Professors: Abdel-Malek, Caudill, Hatch, Ranky, Sebastian, Swart, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Chao, Das, Gage, McDermott
Assistant Professor: Jeng
Special Lecturer: Grosewald

Graduate Advisor: Carl Wolf (201) 596-3657 (Room 2511 GITC), e-mail wolf@admin.njit.edu

Degrees Offered: Master of Science in Engineering Management

■ MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

By drawing on the diverse resources available through the university and surrounding industry, the M.S. in Engineering Management program develops engineers and other technically trained individuals for leadership roles in a technologically-based, project-oriented enterprise. It provides these professionals with broad-based knowledge and skills to succeed as organizational managers and project managers, from conceptualization through implementation. The program is particularly valuable to individuals who have a number of years of experience in industry, government, and service organizations, or those who have been entrepreneurs.

Focus on interdisciplinary coursework and research provides students with an advanced background in both the theoretical and practical (via case studies, role playing, etc.) aspects of managing technical/engineering projects and programs. The engineering management program faculty bring to the classroom a critical blend of practical and academic experience.

Admission Requirements

Eligibility for admission requires completion of an undergraduate degree in engineering, the sciences or a closely related area. Students are expected to have achieved an undergradaute GPA of at least 2.8 on a 4.0 scale. Students not satisfying the above requirement will be considered for conditional admission on a case-by-case basis. In some cases, a bridge program will be required to qualify for matriculation.

Bridge Program—Students who lack appropriate academic preparation may be required to take one or more of the following courses before being admitted to the program. These courses are taken in addition to degree requirements:

EM 501 Industrial Management
EM 502 Engineering Cost Analysis
EM 503 Methods and Applications of Industrial Statistics and Probability

Off-Campus Programs—At the TEC branch campus and at extension and corporate sites, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers this program (as well as part of the bridge program described below) to qualified students who have access to a VCR and personal computer with a modem. In addition, distance-based, 12-credit graduate certificates in Construction Management, in Continuous Process Improvement or in Project Management are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

The program requires 30 credits, 18 of which are taken in a required core. A purpose of the core is to provide knowledge in the functional areas that are the cornerstones of the discipline: Organization and People Management, Cost Management, and Systems Management.

The remaining 12 credits are elective courses, which may be selected to meet the individual's specific professional and personal objectives. In some cases, students may select courses to enhance their technical competency. In other cases, individuals may select courses to prepare for a change in responsibilities or job function. At least half of the elective courses must be selected from those offered by Newark College of Engineering.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

CORE
18 credits:
Acct 615 Strategic Cost Analysis
EM 602 Management Science
EM 636 Project Management
IE 673 Total Quality Management
HRM 601 Organizational Behavior
MIS 648 Decision Support Systems

THESIS (optional)
3 credits: IE 701 Master's Thesis

AREAS OF SPECIALIZATION

Project Management
12 credits:
EM 631 Legal Aspects in Environmental Engineering
EM 637 Project Control
EM 691 Cost Estimating for Capital Projects
IE 651 Industrial Simulation

Cost Engineering
12 credits:
EM 632 Legal Aspects in Construction
{EM 637 Project Control *or*
{IE 618 Engineering Costs and Production Economics
EM 691 Cost Estimating for Capital Projects
Fin 624 Financial Management

Technical Marketing
12 credits:
EM 640 Distribution Logistics
EM 641 Engineering Procurement and Materials Management
Mrkt 631 Market Planning and Analysis
Mrkt 636 Design and Development of High Technology Products

Technological Entrepreneurship
12 credits:
EM 634 Legal, Ethical, and Intellectual Property Issues for Engineering Managers
IE 655 Concurrent Engineering
Mgmt 620 Management of Technology
Mrkt 636 Design and Development of High Technology Products

Quality
12 credits:
EM 674 Benchmarking and Quality Functional Development
IE 605 Engineering Reliability
IE 654 Design for Manufacturability
IE 672 Industrial Quality Control

Facility Management
12 credits:
Arch 650 Economy of Building
EM 632 Legal Aspects in Construction
Fin 624 Financial Management
{IE 653 Facility Maintenance *or*
{OM 678 Factory Management Systems

Engineering Management
12 credits from:
EM 635 Management of Engineering Research and Development
EM 714 Multicriteria Decision Making
IE 618 Engineering Costs and Production Economics
IE 655 Concurrent Engineering
HRM 606 Human Resource Management
MIS 645 Operations Management, Planning and Control

Engineering Science

Administered by: Office of the Dean, Newark College of Engineering
Graduate Advisor: Geraldine Milano (201) 596-5830 (Room 5501 GITC)
Degree Offered: Master of Science in Engineering Science

■ MASTER OF SCIENCE IN ENGINEERING SCIENCE

This is a very flexible program that permits advanced study within numerous areas of specialization in engineering science.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in science, or in engineering. Candidates with other appropriate backgrounds will be considered.

Bridge Program—To ensure academic success in their graduate studies, students may be required to take additional undergraduate or graduate courses before beginning graduate curricula. This program of courses will be individually-designed in consultation with the student's graduate advisor. Such courses are not counted toward degree requirements.

Degree Requirements

A minimum of 30 credits is required. A thesis or project may be included. With the approval of the student's graduate advisor and the Assistant Vice President for Academic Affairs–Graduate Studies, students may take courses offered at the Newark campus of Rutgers, The State University of New Jersey to fulfill degree requirements.

Seminar—In addition to the minimum 30 degree credits, all students who receive departmental or research-based awards must enroll each semester in a graduate seminar. The seminar is selected in consultation with the graduate advisor.

REQUIRED
15 credits, selected in consultation with graduate advisor:
6 credits of 600-level mathematics
3 credits of 600-level physics, chemistry, *or* biological science
6 credits of 600-level engineering courses

ELECTIVE
15 credits selected in consultation with graduate advisor. The elective credits must form a meaningful and coherent program integrated with the specialization in science or engineering.

THESIS OR PROJECT (optional)
3 or 6 credits: selected in consultation with graduate advisor

Environmental Engineering

Administered by: Department of Civil and Environmental Engineering
Chairperson: William R. Spillers
Distinguished Professor: Liskowitz, Spillers
Professors: Chan, Cheng, Dresnack, Golub, Hsieh
Associate Professor: Olenik
Assistant Professors: Axe, Marhaba
Graduate Advisor: Hsin-Neng Hsieh (201) 596-5859, e-mail hsieh@admin.njit.edu
Degrees Offered: Master of Science in Environmental Engineering; Doctor of Philosophy in Environmental Engineering

■ MASTER OF SCIENCE IN ENVIRONMENTAL ENGINEERING

Environmental engineers are essential participants in the planning, design and construction of waste water and potable water treatment plants, solid waste disposal systems, site remediation and emission control measures, and other similar projects. Major corporations, government agencies, private consulting and construction firms, and universities are just some of the organizations that employ environmental engineers.

In-depth knowledge in environmental engineering is essential for professional practice as well as for research. The M.S. in Environmental Engineering is designed for those who want both specialized training and the flexibility to tailor their program to their needs. Courses are taught by full-time faculty members with a range of academic and professional practice experience as well as by adjunct instructors who are experts in their field. Those students interested in research or continuing their education at the Ph.D. level should consider working with faculty involved in one of the related major research centers.

Admission Requirements

Applicants are expected to have an undergraduate degree in engineering or its equivalent.

Bridge Program—Students who lack appropriate background are asked to make up deficiencies by taking a program of courses that is designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements:

CE 320 Fluid Mechanics
CE 321 Water Resources Engineering
CE 322 Hydraulic Engineering
CE 501 Introduction to Soil Behavior
Chem 126 General Chemistry II
CIS 101 Computer Programming
Math 222 Differential Equations
Mech 234 Engineering Mechanics
Mech 236 Dynamics

Note: prerequisites for bridge courses also must be met.

Graduate Certificate Program—A 12-credit graduate certificate in Environmental Site Remediation is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

The program as shown below comprises 30 credits of required and elective courses. The student consults the graduate advisor to plan and maintain an individualized and cohesive sequence of courses.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in EnE 791 Graduate Seminar.

REQUIRED

12 credits as follows:

EnE 560 Chemistry for Environmental Engineers
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 661 Microbiology for Environmental Engineers
Graduate mathematics or computer science course approved by department.

THESIS

Required of those receiving departmental awards; elective for all others.

6 credits: EnE 701 Master's Thesis

ELECTIVE

12 to 18 credits from:

EnE 662 Site Remediation
EnE 664 Physical and Chemical Treatment
EnE 665 Biological Treatment
EnE 666 Analysis of Receiving Waters
EnE 667 Solid Waste Disposal Systems
EnE 668 Air Pollution Control
EnE 669 Water and Wastewater Analysis
EnE 670 Advanced Processes in Water Pollution
EnE 671 Environmental Impact Analysis
EnE 700 Master's Project
EnE 702 Special Topics in Environmental Engineering
CE 601 Advanced Remote Sensing
CE 602 Geographic Information System
CE 604 Environmental Modeling in Remote Sensing
CE 605 Research Methods in Remote Sensing
CE 618 Applied Hydrogeology
CE 620 Open Channel Flow
CE 621 Hydrology
CE 623 Groundwater Hydrology
CE 647 Geotechnical Aspects of Solid Waste
CE 702 Special Topics in Civil Engineering

Other suitable electives may be taken subject to approval of graduate advisor.

■ DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL ENGINEERING

This is a degree for students with master's degrees in environmental engineering, civil engineering, or allied fields who wish to do advanced research in an area of environmental engineering. In exceptional circumstances, highly qualified students with bachelor's degree in environmental engineering or civil engineering may be accepted directly into the doctoral program.

Admission Requirements

Applicants are expected to have superior academic backgrounds in civil engineering, environmental engineering or related fields. A minimum GRE score of 1600 is expected.

Degree Requirements

Candidates must conduct independent original research in a specific area of envirionmental engineering. Specific degree requirements and dissertation topics are approved by the department on an individual basis.

Within one year after being accepted into the doctoral program, candidates must pass a preliminary qualifying examination administered in the department. Candidates must select an advisor to supervise his/her dissertation work and form an advisory committee immediately after passing the preliminary qualifying examinations. Additional information can be found in this catalog under the heading "Academic Policies and Procedures" and from the "Requirements for Doctorate" published by the department.

Seminar—EnE 791 Graduate Seminar is required of all doctoral students each semester.

Environmental Policy Studies

Administered by: Department of Humanities and Social Sciences

Chairperson: Norbert Elliot
Associate Chairperson: Richard Quinn
Program Director: John Opie
Distinguished Professor: Opie (201) 596-6591, e-mail opie@admin.njit.edu
Professors: Beaton, Bordman, Elliot, Geithman, Schweizer
Associate Professors: Franck, Katz
Assistant Professors: Anstine, N. Jackson, Lange, Rothenberg, Sellers

Degree Offered: Master of Science in Environmental Policy Studies

■ MASTER OF SCIENCE IN ENVIRONMENTAL POLICY STUDIES

This program presents a multidisciplinary course of study that emphasizes empirical and analytical methodologies, together with environmental problem solving within a broader social, historical, and ethical framework. In the core courses, students acquire tools to design and assess environmental policy from the disciplines of economics (cost/benefit analysis, risk assessment), geography (spatial analysis and GIS), social psychology (administrative behavior, environmental attitudes and perception), political science (legislative process and administrative law), history (context and precedents of public issues and regulation), and philosophy (ethics and the philosophy of nature).

After completing the core, students have the option of developing independent research seminars with faculty mentors or selecting from more than 20 courses throughout NJIT and at Rutgers-Newark that cover scientific, technological, economic, ethical, historical, and political dimensions of environmental policy studies. Students with a solid background in mathematics and science can enroll in graduate courses in environmental science, civil engineering, and environmental engineering.

NJIT is home to a number of research centers where students can participate in major environmental research, including the Hazardous Substance Management Research Center, the Emissions Reduction Research Center, the Center for Policy Studies, and the Institute for Transportation.

Admission Requirements

Individuals may have an undergraduate degree in natural or physical science, social science, engineering, technology, humanities, and interdisciplinary majors. In some cases, students may need additional preparatory tutorials or courses. Applicants must have an undergraduate degree from an accredited institution with an undergraduate grade point average of at least 3.0 on a 4.0 scale. Graduate Record Examinations (GRE) verbal and quantitative aptitude scores of 1,000 or higher are required. International students must submit a Test of English as a Foreign Language (TOEFL) score of at least 575. A writing sample of no more than five pages of recent work also is required. Letters of recommendation from recent instructors or advisors may be requested.

Graduate Certificate Program—A 12-credit graduate certificate in Environmental Infrastructure and Management is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu.

Degree Requirements

Students must complete a minimum of 30 degree credits. This includes 15 credits in a series of five core courses, followed by 9 elective credits in an area of specialization, and a 6-credit thesis.

Students should develop a thesis topic early in the graduate program in consultation with a faculty advisor. The thesis is the foundation for the course of study. Students then either develop independent research programs with faculty mentors on specific issues related to their interests or select from a number of course offerings in humanities and social sciences or other disciplines at NJIT, including environmental science, environmental engineering, environmental management, transportation or architecture. Students normally complete the program in less than two years.

Seminar—All students who receive departmental or research-based awards must enroll in EPS 698 Special Topics in Environmental Policy, 3 credits, once during the academic year. This will count as elective credit.

CORE

15 credits:

EPS 601 Research Methods
EPS 612 Introduction to Environmental Policy Studies
EPS 613 Environmental History and Policy
EPS 614 Environmental Economics
EPS 660 Ethics and Environmental Policy

THESIS (required)

6 credits: EPS 701 Master's Thesis

ELECTIVE

9 credits:

Courses are chosen in consultation with the graduate advisor. Suggested topics and courses are listed below.

Humanities and Social Sciences

EPS 615 The Politics of Science
EPS 616 Global Problem Solving in Science, Technology and the Environment
EPS 634 Professional Ethics
EPS 644 The Rhetoric of Environmental Policy

Environmental Management

HRM 601 Organizational Behavior
Mgmt 620 Management of Technology
Mgmt 695 Business Strategy for Environmental Management

Transportation

Tran 602 Geographic Transportation Systems
Tran 608 Behavioral Issues in Transportation
Tran 610 Transportation Economics

Political Science

R26:790:504 Comparative Public Policy
R26:790:510 Policy Analysis
R26:790:537,538 Recent International Relations
R26:790:571 American Politics and Public Policy

For students prepared in mathematics and science:

Environmental Science

EM 631 Legal Aspects in Environmental Engineering
EvSc 602 Special Topics in Environmental Science I (environmental health, environmental catalysis, bioremediation)
EvSc 611 Hazardous Waste Management
EvSc 613 Environmental Problem Solving

Environmental Engineering

EnE 560 Chemistry for Environmental Engineers
EnE 660 Introduction to Solid and Hazardous Waste Problems
EnE 661 Microbiology for Environmental Engineers
EnE 662 Site Remediation
EnE 668 Air Pollution Control

Environmental Science

Administered by: Department of Chemical Engineering, Chemistry and Environmental Science

Chairperson: Gordon Lewandowski
Associate Chairperson and Graduate Advisor: Richard Trattner (201) 596-3595, e-mail trattner@admin.njit.edu
Sponsored Chair: Kamalesh Sirkar (membrane separations and biotechnology)
Distinguished Professors: Bozzelli, Lewandowski
Professors: Armenante, Baltzis, Kebbekus, Magee, Perna, Perlmutter, Schuring, Sofer, Trattner
Associate Professors: Barat, Knox, Krasnoperov, Mitra
Assistant Professors: Axe, N. Jackson
Research Professor: Shaw

Rutgers-Newark Faculty

Professors: Kafkewitz, Weis

Degrees Offered: Master of Science in Environmental Science; Doctor of Philosophy in Environmental Science

In 1992, NJIT and the Newark campus of Rutgers, The State University of New Jersey signed a memorandum of agreement. This formalized more than a decade of consortial academic relationships that have strengthened both institutions. Degree programs in environmental science enjoy such collaboration in regard to faculty and course work.

■ MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

This is an interdisciplinary program intended for individuals with backgrounds in science or engineering who want advanced education in the identification, management, treatment and effects of hazardous and toxic materials on the environment.

Admission Requirements

Applicants should have undergraduate degrees in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields who have taken a minimum of one year of college chemistry and mathematics through calculus. Students who lack an appropriate background are required to take a program of courses that is designed in consultation with the graduate advisor. These may include undergraduate courses which are not counted toward degree credit.

A minimum undergraduate grade point average (GPA) of 3.0 on a 4.0 scale, or equivalent, is normally required for admission. Full-time students, and those applying for financial aid, must submit Graduate Record Examinations (GRE) scores. International students must also submit scores in the Test of English as a Foreign Language (TOEFL). International students applying for financial support must achieve a minimum TOEFL score of 550.

Off-Campus Programs—At the New Jersey Department of Environmental Protection (DEP), in Trenton, NJIT also offers courses which are open to non-DEP employees. In addition, 12-credit graduate certificates in Environmental Site Remediation, in Environmental Infrastructure and Management, or in Geographic Information System and Environmental Problems are available as a step toward this degree. For further information about extension programs and graduate certificates call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; cpe@njit.edu

Degree Requirements

A minimum of 30 degree credits is required. Candidates must consult with the graduate advisor (not thesis advisor) in designing appropriate programs of study.

Students must attain a minimum GPA of 3.0 in the core courses listed below, and a minimum overall GPA of 3.0.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in EvSc 600 Environmental Science Seminar, which does not count toward degree credits.

CORE

15 credits:

EvSc 610 Environmental Chemical Science
EvSc 612 Environmental Analysis
EvSc 616 Toxicology for Engineers and Scientists
EM 631 Legal Aspects in Environmental Engineering
R.26:120:604 Microbiology: Principles and Applications

THESIS

Required of those receiving departmental or research-based support; others may choose instead to take two additional courses.
6 credits: EvSc 701 Master's Thesis

ELECTIVE

Courses are offered at NJIT or Rutgers-Newark and selected with the graduate advisor's (not thesis advisor's) approval. 15 credits:

R26:120:551 Biology of Pollution
R26:120:616 Topics in Biology
R26:120:536 Multivariate Biostatistics
R.26:460:577 Seminar in Environmental Geology
EvSc 592 Graduate Work Experience
EvSc 602 Special Topics in Environmental Science I
EvSc 611 Hazardous Waste Management
EvSc 613 Environmental Problem Solving
EvSc 614 Quantitative Environmental Risk Assessment
EvSc 615 Global Environmental Problems
EvSc 620 Environmental Meteorology and Plume Dispersion
EvSc 700 Master's Project
EvSc 702 Special Topics in Environmental Science II
EvSc 711 Advanced Environmental Analysis
EvSc 725 Independent Study I
EvSc 726 Independent Study II
EvSc 727 Independent Study III
CE 618 Applied Hydrogeology
ChE 685 Industrial Waste Control I
ChE 686 Industrial Waste Control II
ChE 687 Industrial Gas Cleaning
ChE 740 Biological Treatment of Hazardous Chemical Wastes
Chem 662 Air Pollution Analysis
Chem 664 Advanced Analytical Chemistry
EnE 660 Introduction to Solid Waste Problems
EnE 662 Site Remediation
EnE 664 Physical and Chemical Treatment
EnE 665 Solid Waste Disposal Systems
EnE 668 Air Pollution Control
EnE 671 Environmental Impact Analysis
EPS 613 Environmental Politics and Policy
EPS 614 Environmental Economics
EPS 660 Ethics and Environmental Policy
IE 615 Industrial Hygiene and Occupational Health
ME 660 Noise Control
ME 661 Thermal Pollution of Water and Air
ME 662 Air Pollution Control and Design

■ DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL SCIENCE

This is a research-oriented degree normally intended for full-time students. Although, initially, courses may be taken on a part-time basis, a minimum of one year of full-time residency is usually required for completion of a dissertation.

Admission Requirements

Normally, a master's degree is required in chemistry, biology, chemical engineering, environmental engineering, environmental science, or related fields. In exceptional circumstances, highly qualified students with bachelor's degrees in those fields may be accepted directly into the doctoral program (see below).

A minimum master's GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550.

Degree Requirements

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Students must attain a minimum overall GPA of 3.0. A minimum of 36 credits of EvSc 790 Doctoral Dissertation and Research, and registration every semester for EvSc 600 Environmental Science Seminar, are required. Should the 36 credits of EvSc 790 be completed before submission of the final dissertation document, students must register for a minimum of 6 credits of EvSc 790 until it has been submitted and accepted. In addition, at least 24 credits of course work beyond the master's degree are required, of which 12 credits must be at the 700-level.

For the required 700-level courses, 6 credits must be in chemical engineering, chemistry, environmental science, or biology. None of these 6 credits may be in Independent Study (EvSc 725, EvSc 726, or EvSc 727). Of the remaining 6 credits of required 700-level courses, no more than 3 credits may be in Independent Study (EvSc 725, EvSc 726, or EvSc 727).

Seminar—All doctoral students must enroll each semester in EvSc 600 Environmental Science Seminar.

Qualifying Examination—All applicants are expected to pass a qualifying examination that tests general competence in environmental sciences at the master's level. It must be taken within the first year following admission to the program, and passed within two years. The examination is offered every January and June. A student will be allowed only two attempts to pass the examination.

Formation of Thesis Committee—Within three months of passing the qualifying examination, doctoral candidates must form a dissertation committee that meets the approval of the graduate advisor in environmental science. As a minimum, the committee must consist of the doctoral candidate's advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal—Within six months of forming the dissertation committee, doctoral candidates must make a formal oral presentation to their committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months (i.e. doctoral students must have an approved dissertation committee and an approved dissertation proposal, within a year of passing the qualifying examination).

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

Admission and Degree Requirements for Exceptional Candidates with Bachelor's Degree Only

Exceptional students with appropriate undergraduate degrees may apply directly for admission to the doctoral program. Applicants are evaluated on a case-by-case basis. A minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is normally required for admission. GRE scores must be submitted. International students must achieve a minimum TOEFL score of 550. If a master's degree is bypassed, students will be required to take a minimum of 78 credits of course work, including at least 36 credits of dissertation.

Students must attain a minimum GPA of 3.0 in the core courses (EvSc 610, EvSc 612, EvSc 616, EM 631, and BIO 26:120:604), and a minimum overall GPA of 3.0.

REQUIRED

51 credits as follows:

EvSc 610 Environmental Chemical Science
EvSc 612 Environmental Analysis
EvSc 616 Toxicology for Engineers and Scientists
EM 631 Legal Aspects in Environmental Engineering
R.26:120:604 Microbiology: Principles and Applications
EvSc 790 Doctoral Dissertation and Research
EvSc 600 Environmental Science Seminar
(Not counted toward degree credit)

ELECTIVE

12 credits from 700-level courses chosen in consultation with the Graduate Advisor. Of these, 6 credits must be in chemical engineering, chemistry, environmental science or biology. None of these 6 credits may be in Independent Study (EvSc 725, EvSc 726, or EvSc 727). Of the remaining 6 credits, no more than 3 credits may be in Independent Study (EvSc 725, EvSc 726, or EvSc 727).

6 credits from 600- or 700-level courses in chemical engineering, chemistry, environmental science, or biology.

9 credits from any 600- or 700-level course.

Qualifying Examination—A qualifying exam must be taken within three semesters of admission to the program, and passed within two years. The examination is offered every January and June. A student will only be allowed two attempts to pass the examination.

Formation of Thesis Committee—Within three months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate advisor in environmental science. As a minimum, the committee must consist of the doctoral candidate's advisor, three additional faculty members from the department, and one member from outside the department.

Research Proposal—Within six months of forming the dissertation committee, doctoral students must make a formal oral presentation to their dissertation committee and other interested persons on the scope of their proposed research. The committee must formally approve the proposal within a maximum of three additional months (i.e. doctoral candidates must have an approved dissertation committee and an approved dissertation proposal, within a year of passing the qualifying examination).

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval. Signatures of all members of the dissertation committee must be received for final approval to be granted.

If students are unable to complete the requirements for the degree, they may become a candidate for the Master of Science in Environmental Science upon completion of requirements for that degree.

History

Administered by: Federated History Department of NJIT and Rutgers-Newark

Chairperson: Lauren Benton
Associate Chairpersons: Richard Sher (NJIT), Gabor Vermes (Rutgers)
Director, Graduate Programs: Jan E. Lewis (201) 648-5411 (Room 317, Conklin Hall, Rutgers)
Graduate Coordinator of History of Technology, Environment and Medicine: Richard Sher (201) 596-3377 (Room 403 CUL, NJIT), e-mail sher@admin.njit.edu

NJIT Faculty

Professors: O'Connor, Schweizer, R. Sher
Associate Professor: Benton
Assistant Professor: Sellers

Rutgers-Newark Faculty

Robert Treat Professor: Kimball
Professors: Basch, Dain, Golden, Hunczak, Lewis, Lurie, Price, Samatar, Wou
Associate Professors: Hosford, Merker, Russell, Vermes, Wagenheim
Assistant Professors: Cowans, Satter

Degrees Offered: Master of Arts in History, Master of Arts in Teaching (History) Both degrees are conferred jointly by NJIT and Rutgers University-Newark, with the names of both universities appearing on all diplomas. Students interested in History of Technology, Environment and Medicine should contact the graduate coordinator and apply to NJIT; students interested in American History, World History or the master's in teaching for history should contact the graduate director and apply to Rutgers-Newark.

The Federated History Department offers the Master of Arts for generalists and for students interested in preparing for further graduate study in history, and the Master of Arts in Teaching for current and prospective secondary school teachers of history and social studies. The objective of the graduate history program is to furnish a broad yet rigorous course of study in preparation for careers in teaching, business, law, government, administration, and other fields related to history, as well as to enhance the professional experience and increase the opportunities for advancement of students who are already working as professionals in these fields.

Program administration and teaching are shared by faculty from both campuses, and the full resources of both universities are available to all history graduate students and faculty. Resources include access to the Rutgers University library system of more than three million volumes, to the outstanding collection in the history of medicine at the University of Medicine and Dentistry of New Jersey, and to excellent history collections in the region. A special relationship with the Thomas Edison National Historic Site in nearby West Orange provides students with access to rich archival materials.

The joint NJIT/Rutgers-Newark graduate history program is the largest and most diverse masters-level history program in New Jersey. Many of the graduate faculty have national or international reputations as scholars, representing a wide variety of time periods and fields of study. The program is particularly noted for its strengths in en-

vironmental history and the history of science, technology and medicine; cultural and intellectual history; foreign policy and diplomatic history; history of women; eighteenth-century studies; African and African-American history; legal history; and global and comparative history.

■ MASTER OF ARTS IN HISTORY

Admission Requirements

Applicants must have an undergraduate degree from an accredited institution and favorable letters of recommendation from professors familiar with their work. An undergraduate GPA of at least 3.0 and an acceptable score on the verbal portion of the Graduate Record Examinations are normally required.

Bridge Program—Students who lack appropriate undergraduate preparation for the program are required to make up deficiencies by taking a program of courses designed in consultation with the graduate advisor. Bridge courses are not counted toward degree credit.

Note: Students interested in History of Technology, Environment and Medicine should apply to NJIT; students interested in American History or World History should apply to Rutgers-Newark.

Degree Requirements

A minimum of 30 credits is required: 18 in a major field and 6 in a minor field chosen in consultation with a faculty advisor. The remaining 6 credits may be completed through additional course work or a thesis. A comprehensive examination is also required. Students must demonstrate basic reading ability in a foreign language.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in Hist 791 Graduate Seminar.

THESIS (optional)
6 credits: Hist 701 Master's Thesis

Major Fields

Although faculty from NJIT and Rutgers-Newark teach in all three of the major fields, NJIT has primary administrative responsibility for History of Technology, Environment and Medicine. Rutgers-Newark has primary administrative responsibility for the major fields in American History and World History.

History of Technology, Environment and Medicine

This field is unique in its integration of three relatively new and increasingly important historical sub-disciplines. Their rapid growth in recent years reflects greater awareness among professional historians and the general public of the significance of broader issues concerning technology, the environment, and medicine in contemporary life. As these issues loom larger in the consciousness of society, so does the need to learn more about their historical origins, causes, and patterns of development. The department has a distinguished concentration of faculty in these areas, with particular strengths in American environmental history; the social and cultural history of medicine and technology (including gender issues); industrial medicine; history of mental health; history of printing and communications; and technology and warfare.

A sample curriculum for a major field in History of Technology, Environment and Medicine and a minor field in American History to 1865 is shown below.

MAJOR

18 credits:

Hist 622	Culture and Science in the History of American Medicine
Hist 624	Technology, Environment and Medicine in World History
Hist 628	Gender, Science, and Technology in the Modern World
Hist 632	Technology, Culture and History
Hist 634	Environmental History of North America
Hist 638	War, Technology and Society, 1500-1914

MINOR

6 credits:
R26:510:576 Topics in American History, 1492-1789
R26:510:577 Topics in American History, 1789-1865

THESIS
6 credits: Hist 701 Master's Thesis

American History

This field examines the history of the United States from its foundations to the present day. The department is particularly noted for its strengths in social, cultural, and diplomatic history; the history of women and the family; African-American history; legal history; and the history of science, medicine, and the environment.

World History

This major field covers Europe and the non-Western world and is particularly concerned with global interaction and comparative history across national and chronological boundaries. The department offers a wide range of global coverage, including courses on Africa, China, Eurasia, Latin America, Russia, and Eastern Europe; comparative colonial and economic history; and British and European intellectual, cultural, and diplomatic history.

■ MASTER OF ARTS IN TEACHING (History)

The Master of Arts in Teaching (M.A.T.) is a terminal degree for students who are preparing for, or are already engaged in, careers in secondary school teaching in history and social studies. See Rutgers-Newark graduate catalog for more information.

Admission Requirements

Admission to the M.A.T. program is automatic for any applicant currently engaged in full-time teaching at the secondary level. All others should see admission requirements described under Master of Arts in History.

Degree Requirements

Successful completion of 30 credits of course work, at least 18 in graduate history courses, and up to 12 in approved education courses. Students must maintain a grade point average of at least 3.0, with not more than two grades of C, and submit a sample research paper written for a graduate history class.

Industrial Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Paul G. Ranky
Associate Chairperson: Kevin J. McDermott
Program Director: George Abdou
Professors: Abdel-Malek, Caudill, Hatch, Ranky, Sebastian, Swart, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Chao, Das, Gage, McDermott
Assistant Professor: Jeng

Graduate Advisor: Sanchoy Das (201) 596-3654, e-mail das@admin.njit.edu

Degrees Offered: Master of Science in Industrial Engineering; Doctor of Philosophy in Industrial Engineering

■ MASTER OF SCIENCE IN INDUSTRIAL ENGINEERING

A program for individuals who seek professional advancement in the industrial engineering field.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in industrial engineering or related fields.

Bridge Program—Students who do not have a bachelor of science degree in industrial engineering will be required to complete the following Bridge Program. These courses do not count toward degree requirements:

IE 501 Fundamentals of Industrial Engineering
EM 502 Engineering Cost Analysis
EM 602 Management Science

Degree Requirements

A minimum of 30 credits beyond a baccalaureate degree is required. A master's thesis is optional. Students select an area of specialization and individually design their programs in consultation with the graduate advisor. Faculty advisor approval must be obtained by students before they are permitted to register for IE 701 Master's Thesis.

At the discretion of a department advisor, students may take courses at other universities.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

CORE

12 credits:

IE 604 Advanced Engineering Statistics
IE 618 Engineering Cost and Production Economics
IE 621 Application of Digital Computers in Industrial Engineering
IE 650 Advanced Topics in Operations Research

THESIS (optional)

6 credits: IE 701 Master's Thesis

AREAS OF SPECIALIZATION

The range of possible specializations is broad. Students should consult the graduate advisor in designing specializations and related degree requirements. The following is a list of possible specializations and suggested electives.

18 credits are selected from an area of specialization with the approval of the graduate advisor.

Quality and Reliability Engineering

EM 635 Management of Engineering Research and Development
EM 640 Distribution Logistics
IE 605 Engineering Reliability
IE 606 Maintainability Engineering
IE 608 Product Liability Control
IE 616 Planning and Control of Products and Processes
IE 672 Industrial Quality Control

Cost Engineering

EM 636 Project Management
EM 691 Cost Estimating for Capital Projects
EM 693 Managerial Economics
EM 771 Operations Cost and Management Control
IE 605 Engineering Reliability
IE 606 Maintainability Engineering
IE 618 Engineering Cost and Production Economics
IE 641 Operations Analysis
IE 651 Industrial Simulation
IE 653 Facility Maintenance
IE 672 Industrial Quality Control

Operations Research and Decision Sciences

EM 714 Multicriteria Decision Making
IE 605 Engineering Reliability
IE 616 Planning and Control of Products and Processes
IE 623 Linear Programming
IE 624 Heuristic Methods
IE 651 Industrial Simulation
IE 652 Facilities Location and Plant Layout
IE 672 Industrial Quality Control
IE 704 Sequencing and Scheduling
IE 705 Mathematical Programming in Management Science
IE 706 A Queuing Approach to Performance Evaluation

Human Factors/Ergonomics

IE 605 Engineering Reliability
IE 612 Robotic Manufacturing Systems
IE 613 Manufacturing Engineering
IE 614 Safety Engineering Methods
IE 615 Industrial Hygiene and Occupational Health
IE 670 Industrial Work Physiology
IE 672 Industrial Quality Control
IE 675 Safety in Facility and Product Design
IE 760 Quantitative Methods in Human Factors Engineering
ME 660 Noise Control
ME 662 Air Pollution Control and Design
ME 670 Introduction to Biomechanical Engineering
ME 671 Biomechanics of Human Structure and Motion

Production and Manufacturing Systems

CIS 610 Data Structures and Algorithms
CIS 651 Data Communications
EM 655 Management Aspects of Information Systems
IE 612 Robotic Manufacturing Systems
IE 613 Manufacturing Engineering
IE 616 Planning and Control of Products and Processes
IE 618 Engineering Cost and Production Economics
IE 654 Design for Manufacturability
IE 655 Concurrent Engineering
IE 656 Flexible and Computer Integrated Manufacturing
ME 635 Computer-Aided Design

Service Systems

CIS 632	Advanced Data Base System Design
EM 636	Project Management
HRM 606	Human Resource Management
IE 624	Heuristic Methods
IE 641	Operations Analysis
IE 651	Industrial Simulation
IE 652	Facilities Location and Plant Layout
IE 673	Total Quality Management
MIS 545	Management Information Systems

Systems Analysis

CIS 505	Programming, Data Structures, and Algorithms
CIS 631	Data Management System Design
CIS 673	Software Design and Production Methodology
CIS 676	Requirements Engineering
EM 636	Project Management
EM 691	Cost Estimating for Capital Projects
IE 624	Heuristic Methods
IE 651	Industrial Simulation
IE 655	Concurrent Engineering
IE 673	Total Quality Management

■ DOCTOR OF PHILOSOPHY IN INDUSTRIAL ENGINEERING

The objectives of the Ph.D. in Industrial Engineering program are to provide the knowledge and develop the skills that students need to become leaders of research in academia, industry and government.

This program is intended for highly qualified students who wish to pursue advanced research in industrial engineering and related areas. It emphasizes two areas: (1) Manufacturing Systems and Assurance Sciences and (2) Human Factors and Occupational Safety.

Admission Requirements

Applicants should have a master's degree in industrial engineering or a related field. In certain circumstances, a qualified student with a bachelor's degree in industrial engineering or related field may be admitted into the program.

Degree Requirements

A minimum of 60 degree credits is required as follows: 36 credits of dissertation research and 24 credits of course work beyond the master's degree, 12 credits of which must be at the 700-level and none at the 500-level. Of the 24 credits of course work, 12 credits are core courses and the other 12 credits are techncal electives. Registration for IE 791 is required each semester for all students.

If the 36 credits of dissertation research are completed before the dissertation is finished, candidates must register each semester for at least 3 credits of dissertation research until the dissertation is accepted.

Students with bachelor's degrees who are admitted into the doctoral program must complete a minimum of 42 credits of course work and at least 36 credits of dissertation research.

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Before being permitted to register for dissertation research, students must complete course requirements, pass qualifying examinations, both written and oral, and demonstrate that there are facilities and a faculty member available to supervise the research.

Qualifying Examinations—All doctoral candidates are expected to pass both a written and oral qualifying examination. Passing the written qualifying examination is a prerequisite for the oral examination. Students are urged to take these examinations as soon as possible after being admitted into the program.

Students must take a two-part *written examination* within the first year following admission to the program, and pass within two years. The examination is offered every October. A student will be allowed only two attempts to pass the examination. Both parts must be taken at the same time. It consists of two sections:

Section I General competence in mathematics including calculus, probability and statistics, differential equations, and linear algebra.
Section II Proficiency in fundamentals of industrial engineering including: operations research (deterministic and probabilistic), quality control, reliability, engineering economy, production planning and control, and human factors.

The *oral examination* should be taken and passed in the semester after the written examination is passed. The dissertation committee assigns a topic for the oral examination from the student's area of specialization. The examination is offered by the dissertation committee. Thorough study and understanding of theoretical, technical and practical aspects of the assigned topic should be demonstrated in the oral examination.

Formation of a Dissertation Committee—With the approval of the graduate advisor, within two months after passing the written examination, students must form a dissertation committee. The committee should consist of at least four faculty members from the department including the student's advisor. In addition, one member of the committee should be chosen from outside the department.

Dissertation Proposal—Within three months of passing the oral examination, candidates must submit, for the approval of their dissertation committee, both in writing and orally, a doctoral proposal on the scope of their proposed research.

The dissertation must represent original research leading to meaningful advances in the industrial engineering profession. The work must be worthy of publication in refereed journals on industrial engineering or related fields. Doctoral students must complete dissertation research in the five years subsequent to passing their written and oral qualifying examinations.

Dissertation Defense—Each doctoral student must submit to their committee a written dissertation for their approval. After the dissertation committee approves the document, the student must successfully defend their dissertation research in front of the committee and other interested faculty and students.

AREAS OF SPECIALIZATION

Manufacturing Systems and Assurance Sciences

CORE
12 credits:

IE 654	Design for Manufacturability
IE 704	Sequencing and Scheduling
IE 705	Mathematical Programming in Management Science
IE 706	A Queuing Approach to Performance Analysis
IE 791	Graduate Seminar (Non-credit)

ELECTIVE
12 credits, 3 credits of which must be at the 700-level:
Courses selected from IE, ME, MnE, CIS, and Math.

Human Factors and Occupational Safety

CORE
12 credits:

IE 604	Advanced Engineering Statistics
IE 760	Quantitative Methods in Human Factors Engineering
IE 761	Advanced Studies in Human Factors
IE 762	Psychophysical Methods for Human Factors
IE 791	Graduate Seminar (Non-credit)

ELECTIVE
12 credits, 3 credits of which must be at the 700-level:
Courses selected from IE, ME, ChE, CIS, and Math.

Infrastructure Planning

Administered by: School of Architecture

Program Director: Antonio de Souza Santos (201) 596-3029, e-mail mip@admin.njit.edu
Associate Program Director: Darius Sollohub
Distinguished Professors: Mostoller, Opie, Pignataro
Professors: Celik, Dauenheimer, Ehrenkrantz, Elliot, Gauchat, Goldman, Hasan, Hawk, Konon, Papademetriou, Santos, Schuman, Wecharatana
Associate Professor: Franck
Assistant Professor: Lange

Degree Offered: Master in Infrastructure Planning

■ MASTER IN INFRASTRUCTURE PLANNING

A unique interdisciplinary program in infrastructure planning and design directed at students with previous degrees in architecture, landscape architecture, urban planning or civil engineering. Through interdisciplinary teaching, research and practice made possible by NJIT's resources in architecture, civil and environmental engineering, transportation, environmental policy studies, and industrial management, the program addresses the global need to train planning and design professionals capable of acting across the spectrum of disciplines involved in infrastructure development.

Infrasructure is defined as the whole built fabric of public spaces, institutions, facilities and services that shapes and sustains daily life. The traditional identification of different infrastructure components with separate professional disciplines has restricted the development of holistic strategies for building more livable and efficient urban environments. The goal of the program is to gain a coherent understanding of the interrelationships between those components and to develop the potential of integrally planned and designed infrastructure systems to deal more effectively with the critical problems confronting our cities.

Using a variety of project settings in North America and abroad, the program focuses on the natural environment and on public space, roads, transportation, services and utilities as interacting physical and spatial systems, as well as on parks, schools, housing and civic institutions of all kinds. The purpose is to develop coherent operational strategies that integrate the broadest possible range of planning and design policies, methods and actions for improving human settlements; and to resolve in environmental terms the larger social and political issues that affect the quality of life in our communities.

Capitalizing on NJIT's multidisciplinary resources and location at the center of the nation's greatest regional concentration of urban infrastructure, the M.I.P. program incorporates applied research and realistic problem solving in its curriculum and also offers internships and research assistantships. M.I.P. faculty, drawn from the university's four academic divisions, is supplemented by eminent infrastructure planning practitioners. Collaborative relationships are being established with complementary academic programs at Rutgers University and with regional, national and international institutions concerned with infrastructure. A number of notable research facilities at NJIT engage in related specialized work and the Infrastructure Design Laboratory promotes interdisciplinary research and consulting specifically in the area of infrastructure planning and design.

Dual Degree Programs: Dual M.Arch./M.I.P. or M.S./M.I.P. degree options that reduce the number of credits required to obtain the two degrees separately are available to students with superior academic records who hold professional bachelor's degrees in architecture or engineering from NJIT or equivalents; or who are prospective graduates of the professional M.Arch. program at NJIT. See "Architecture" for the M.Arch./M.I.P dual degree program description.

Admission Requirements

Applicants must have a bachelor's or a master's degree in architecture, landscape architecture, urban planning, or engineering. A GPA of at least 3.0 is expected and evidence of potential for graduate study is to be demonstrated by a portfolio, letters of recommendation, GRE scores, and TOEFL scores in the case of international students.

Bridge Course—Students not sufficiently experienced in design will be required to take an intensive bridge course in design prior to entering the program.

Degree Requirements

Students must complete 51 course credits through full- or part-time study over a minimum of three semesters. Up to 9 credits may be transferred as exemptions from areas of previous specialization. Additional elective courses may be taken in disciplines related to infrastructure planning, but do not count toward degree credit.

REQUIRED

The following courses are required, subject to exemptions allowed in individual cases; however, no exemptions will be given from studio courses. A typical full-time study plan over three semesters is shown below; degree credits are in parenthesis.

Semester 1
MIP 601 Interdisciplinary Infrastructure Studio I (6)
MIP 631 History and Theory of Urban Infrastructure (3)
MIP 673 Introduction to Infrastructure Planning (3)
MIP 675 Elements of Urban Infrastructure (3)
MIP 691 Legal and Ethical Issues (3)

Semester 2
MIP 602 Infrastructure Technology Studio II (6)
MIP 612 Introduction to Environmental Policy (3)
MIP 618 Public and Private Financing of Urban Areas (3)
MIP 643 Introduction to Urban Transportation Planning (3)
MIP 668 Development of Urban Planning (3)

Semester 3
MIP 603 Interdisciplinary Infrastructure Studio III (6)
MIP 650 Urban Systems Engineering (3)
MIP 669 Infrastructure Financing and Strategy (3)
MIP 674 Infrastructure and Architecture (3)

Interdisciplinary Studies

Administered by: Department of Humanities and Social Sciences
Program Director: John Opie (201) 596-6591, e-mail opie@admin.njit.edu
Graduate Advisors: faculty from NJIT's four colleges, as appropriate
Degree Offered: Master of Science in Interdisciplinary Studies

■ MASTER OF SCIENCE IN INTERDISCIPLINARY STUDIES

This program is designed for students seeking graduate work at NJIT that involves one or more departments and/or colleges and those seeking proficiency in a subject not specified by an existing degree program. Emphasis is placed upon the relationship between a technological field and the social sciences. Examples include environmental law or journalism, urban land use policy, economic forecasting, and sports management. Students can take courses at Rutgers-Newark in related areas. This program is designed for professionals whose careers require proficiency across several technical and non-technical disciplines. It also provides opportunities for graduate students with non-traditional preparation.

Admission Requirements

Applicants must have an undergraduate degree from an accredited institution with preparation in a technological or social science field. Applicants are expected to have an undergraduate GPA of at least 3.0. Graduate Record Examinations (GRE) scores are required.

Bridge Program—Students who lack appropriate undergraduate preparation for interdisciplinary studies are required to make up deficiencies by taking a course or program of courses designed in consultation with the graduate advisor. Bridge courses are not counted toward degree credit.

Degree Requirements

A minimum of 30 degree credits is required, including 9 credits in a core, 15 elective credits in an area of specialization, and 6 credits of thesis, project, or directed field work or internship. A series of core courses, designed for each student depending upon their concentration, introduces essential methodologies, disciplines and fields. Programs will be designed individually in consultation with the program director and graduate advisors.

Seminar—In addition to the minimum 30 degree credits required, all students who received departmental or research-based awards must enroll each semester in an appropriate seminar that will be determined in consultation with the graduate advisor.

AREAS OF SPECIALIZATION

The three sample programs described below are not formalized curricula, but represent how a graduate student and faculty advisor in interdisciplinary studies might develop a series of courses.

Environmental Law

CORE
9 credits:
EM 631 Legal Aspects in Environmental Engineering
EPS 612 Introduction to Environmental Policy Studies
Mgmt 695 Business Strategy for Environmental Management

DIRECTED FIELD WORK (required)
6 hours:
Internship in a law firm, government agency, or industrial operation

ELECTIVE
15 credits:
EPS 614 Environmental Economics
EPS 660 Ethics and Environmental Policy
EvSc 613 Environmental Problem Solving
R26:790:510 Policy Analysis
R26:790:571 American Politics and Public Policy

Economic Forecasting

CORE
9 credits:
EnE 671 Environmental Impact Analysis
EPS 601 Research Methods
EPS 641 Workshop in Technology Assessment

THESIS, PROJECT OR INTERNSHIP (required)
6 credits

ELECTIVE
15 credits:
Arch 650 Economy of Building
EM 660 Financing an Industrial Enterprise
EM 691 Cost Estimating for Capital Projects
EPS 614 Environmental Economics
Fin 618 Public and Private Financing of Urban Areas

Sports Management

CORE
9 credits:
BINF 5005 Health Care Information Systems
Fin 624 Financial Management
HRM 601 Organizational Behavior

DIRECTED FIELD WORK (required)
6 credits

ELECTIVE
15 credits:
BINF 5125 Clinical Problem Solving and Decision Making
Eng 642 Professional Writing
HRM 606 Human Resource Management
IE 615 Industrial Hygiene and Occupational Health
IE 670 Industrial Work Physiology

Management

Administered by: School of Industrial Management

Dean: Alok Chakrabarti
Distinguished Professors: Chakrabarti, Kirchhoff, Turoff
Sponsored Chair: Alok Chakrabarti (management of technology)
Director, Executive Program: George Albright (201) 596-6378, e-mail albright@admin.njit.edu
Professors: Hasan, Hawk, Lawrence, Rotter, Schachter
Associate Professors: Bonitsis, Cordero, Kahng, Somers, Spasovic, Sylla
Assistant Professors: Anandarajan, Anyanwu, Bartolacci, T.L. Chang, Fjermestad, Heller, Kleinman, Mathis, Walsh, Wen
Visiting Professors: Banerjee, Sen
Special Lecturers: P. Albright, Havlena
Professional/Instructional Staff: Wachspress, Worrell

Graduate Advisor: Malcolm Worrell (201) 596-3262 (Room 3011CAB), e-mail worrell@admin.njit.edu

Degree Offered: Master of Science in Management; Doctor of Philosophy in Management, offered by Rutgers, The State University of New Jersey

■ MASTER OF SCIENCE IN MANAGEMENT

A program for individuals who wish a career in managing an industrial or technology-based organization.

Executive Program—An intensive, accelerated course of study for carefully selected candidates. Course work is completed on alternate weekends for approximately 14 months. Students in this program will focus on global competitiveness, use of technology, management of information, total quality, environmental and ethical issues in business.

Dual Degree Program—There is a dual degree program for the Bachelor of Architecture or professional Master of Architecture and Master of Science in Management. A description for the dual degree may be found under the Architecture degree program section of this catalog.

Admission Requirements

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, probability and statistics, accounting and a knowledge of computer programming.

Bridge Program—Students obtaining a degree in management are expected to have knowledge of the primary management disciplines: managerial accounting, managerial economics, finance, management information systems, operations research, and marketing. Students who have made a satisfactory grade in undergraduate courses in these areas are not required to take them again. Students who are deficient in these areas are required to take the following courses unless they receive approval for a waiver from the dean or the graduate advisor. These courses do not count toward degree requirements unless they are stated as a requirement in a specific program, such as Fin 516 in the Dual program with Architecture, these courses will not count toward degree requirements. Students who feel that they have extenuating circumstances may request that one of them be used toward degree requirements. The request must be directed to the Dean of the School of Industrial Management. The Bridge Program is not required for those specializing in Environmental Management.

Acct 515 Accounting for Managerial Control
Econ 565 Managerial Economics
Fin 516 Principles of Financial Management
Mgmt 580 Managerial Science
MIS 545 Management Information Systems
Mrkt 530 Principles of Marketing

Off-Campus Programs—At extension sites, NJIT offers many courses required to fulfill degree requirements. All courses are taught by NJIT faculty. For locations, see "Extension Programs" in this catalog. The university's distance learning arm, ACCESS/NJIT, offers a part of the bridge program described below to qualified students who have access to a VCR and personal computer with a modem. In addition, 12-credit graduate certificates in Health Care Information Systems or in Environmental Infrastructure and Management are available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu

Degree Requirements

A minimum of 30 credits is required for all areas of specialization except Environmental Management, which requires 45 credits. At the discretion of the graduate advisor and with the approval of the Dean, students may take appropriate courses at Rutgers-Newark or the University of Medicine and Dentistry of New Jersey. Degree candidates must exercise one of two options in completing their degree programs:
Option I—24 credits of course work, plus 6 credits of thesis (not available in the Entrepreneurship, Environmental Management, Management Accounting and Auditing areas of specialization).
Option II—30 credits of course work.

Seminar—In addition to the minimum 30 or 45 degree credits required, all students who receive school or research-based support must enroll each semester in Mgmt 791 Graduate Seminar.

CORE

For all specializations below except Environmental Management, *9 credits:*
HRM 601 Organizational Behavior
Mgmt 691 Legal and Ethical Issues
Mgmt 692 Business Strategy

THESIS
Required if exercising Option I
6 credits: see the area of specialization for appropriate course.

AREAS OF SPECIALIZATION

Entrepreneurship

CORE
9 credits: As described

REQUIRED
9 credits:
Mgmt 640 New Venture Management
Mgmt 645 New Venture Finance
Mgmt 680 Entrepreneurial Strategy

ELECTIVE
9 credits from:
Acct 615 Concepts of Strategic Cost Analysis
IE 673 Total Quality Management
Fin 631 Working Capital Management and Credit Analysis
Fin 632 Financial Valuation of Technology-Based Companies
HRM 606 Human Resource Management
HRM 630 Managing Technological and Organizational Change
Mgmt 620 Management of Technology
MIS 630 Models of Consumer Behavior
Mrkt 636 Design and Development of High-Technology Products
Mrkt 638 Sales Management for Technical Professionals
Mrkt 642 International Marketing Management

3 credits selected in consultation with graduate advisor

THESIS
Not offered in this area of specialization

Environmental Management

CORE
Replaces above
21 credits:
Acct 615 Concepts of Strategic Cost Analysis
Econ 565 Managerial Economics
EM 636 Project Management
EvSc 622 Survey of Environmental Science and Technology
Fin 516 Principles of Finance
MIS 690 Executive Information Systems
Mrkt 640 Industrial Marketing Management

REQUIRED
18 credits:
EM 631 Legal Aspects in Environmental Engineering
EvSc 613 Environmental Problem Solving
EvSc 614 Quantitative Risk Assessment *or*
Mgmt 640 New Venture Management
HRM 601 Organizational Behavior
Mgmt 620 Management of Technology
Mgmt 695 Business Strategy for Environmental Management

ELECTIVE
6 credits from:
EM 691 Cost Estimating in Capital Projects
Fin 624 Financial Management
HRM 606 Human Resource Management
HRM 693 Employment Relations and the Law
Mgmt 655 Global Competitiveness
Mrkt 631 Market Planning and Analysis
Mrkt 636 Design and Development of High-Technology Products

THESIS
Not offered in this area of specialization

Financial Management

CORE
9 credits: As described

REQUIRED
6 credits:
Fin 624 Financial Management
Fin 626 Financial and Investment Institutions

ELECTIVE
6 or 12 credits from:
Acct 690 Seminar in Taxation
Fin 618 Public and Private Financing of Urban Areas
Fin 627 International Finance
Fin 630 Applied Business Econometrics
Fin 631 Working Capital Management and Credit Analysis
Fin 632 Financial Valuation of Technology-Based Companies
Fin 634 Mergers, Acquisitions, and Restructuring
Fin 660 Financial Planning and Decision Making
Fin 700 Seminar in Theory and Research in Financial Management

3 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others.
6 credits:
Fin 701 Methods of Research in Financial Management

Human Resource Management

CORE
9 credits: As described

REQUIRED
6 credits:
HRM 606 Human Resource Management
HRM 607 Personnel and Evaluation Research
6 or 12 credits from:
HRM 608 Behavioral Issues in Transportation Studies
HRM 609 Employee Training and Development
HRM 616 Job Analysis and Design
HRM 630 Managing Technological and Organizational Change
HRM 640 Seminar on Cultures in Organizations
HRM 650 Human Resource Information Systems
HRM 655 Theory and Research in Organizational Behavior
HRM 660 Issues in Technology-Based Organizations
HRM 662 Organizational Behavior and Development
HRM 693 Employment Relations and the Law

3 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others.
6 credits:
HRM 701 Methods of Research in Human Resources Management (Master's Thesis)

Information Systems Management

CORE
9 credits: As described

REQUIRED
6 credits:
MIS 645 MIS Operations, Management, Planning, and Control
MIS 648 Decision Support Systems
6 or 12 credits from:
CIS 631 Data Management System Design
CIS 635 Computer Programming Languages
CIS 661 System Simulation
CIS 671 Knowledge-Based Systems
CIS 675 Information Systems Evaluation
CIS 679 Management of Computer and Information Systems
HRM 650 Human Resource Information Systems
MIS 620 Computing Concepts for Managers
MIS 635 Management of Telecommunications
MIS 640 Auditing Business Information Systems Being Developed
MIS 654 Design of Accounting Information Systems
MIS 655 Informational Systems Audit, Control and Security
MIS 680 PC Tools for Managers
MIS 690 Executive Information Systems

3 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others
6 credits:
MIS 701 Methods of Research in Information Systems Management

International Business

CORE
9 credits: As described above

REQUIRED
6 credits:
Mgmt 655 Global Competiveness
Mgmt 670 International Business

ELECTIVE
6 or 12 credits from:
Fin 627 International Finance
HRM 685 Cross Cultural Management Studies
Mgmt 657 Import/Export Processes
Mgmt 660 Global Communications
Mgmt 665 International Product Development
Mgmt 675 Legal Environment of Business
Mrkt 642 International Marketing Management

3 credits selected in consultation with graduate advisor.

THESIS
Required if exercising Option I; elective for all others
6 credits:
Appropriate course selected in consultation with the graduate advisor

Marketing Management

CORE
9 credits: As described

REQUIRED
6 credits:
Mrkt 630 Models of Consumer Behavior
Mrkt 631 Marketing Planning and Analysis
6 or 12 credits from:
EM 714 Multicriteria Decision Making
Mgmt 710 Business Forecasting Methods
Mgmt 731 Advanced Market Planning and Analysis
Mrkt 632 Marketing Strategy for Technology-Based Organizations
Mrkt 636 Design and Development of High-Technology Products
Mrkt 637 Marketing Communications and Promotions
Mrkt 638 Sales Management for Technical Professionals
Mrkt 640 Industrial Marketing Management
Mrkt 642 International Marketing Management
Mrkt 753 Marketing Science

3 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others
6 credits:
Mrkt 701 Methods of Research in Marketing Management

Operations Management and Systems

CORE
9 credits: As described

REQUIRED
6 credits:
Mgmt 620 Management of Technology
MIS 648 Decision Support Systems
6 or 12 credits from:
Acct 675 Cost-Value Analysis
EM 636 Project Management
EM 691 Cost Estimating for Capital Projects
EM 715 Design of the Enterprise
IE 613 Manufacturing Engineering
IE 618 Engineering Cost and Production Economics *or*
Acct 615 Concept of Strategic Cost Analysis
IE 641 Operations Analysis
IE 656 Flexible and Computer Integrated Manufacturing
IE 673 Total Quality Management
Mgmt 650 Leadership for Total Quality Management
Mgmt 655 Global Competitiveness

3 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others
6 credits:
OM 701 Methods of Research in Operations Management

Transportation Management

CORE
9 credits: As described

REQUIRED
9 credits:
Tran 640 Distribution Logistics
Tran 643 Transportation Finance
Tran 765 Multi-modal Freight Transportation Systems Analysis

6 credits selected in consultation with graduate advisor

THESIS
Required if exercising Option I; elective for all others
6 credits: Tran 701 Master's Thesis

Management Accounting and Auditing

CORE
9 credits: As described

REQUIRED
9 credits:
Acct 615 Concepts of Strategic Cost Analysis
MIS 654 Design of Accounting Information Systems
MIS 655 Information Systems Audit, Control, and Security

ELECTIVE
12 credits from:
Acct 610 Concepts of Internal Auditing
Acct 630 Concepts and Applications of Control
Acct 650 Operational Auditing
Acct 670 Seminar in Accounting Theory
Acct 675 Cost Value Analysis
Acct 680 Seminar in Auditing
Acct 690 Seminar in Taxation
Fin 634 Mergers and Acquisitions
MIS 620 Computing Concepts for Managers
MIS 630 Accounting and Auditing Software
MIS 640 Auditing Information Systems Being Developed

THESIS
Not offered in this area of specialization

■ DOCTOR OF PHILOSOPHY IN MANAGEMENT

Director for computer information and systems specialization: Murray Turoff (201) 596-3399 (Room 4106 GITC)

The Department of Computer and Information Science and the School of Industrial Management at NJIT cooperate with the Rutgers Graduate School of Management in this program. Admission to the program is handled by Rutgers-Newark; the degree is conferred by Rutgers, The State University of New Jersey.

The advisement for the specialization in computer information and systems is provided through the CIS department and a significant number of courses for this specialization are offered by NJIT.

This specialization concerns the design, development, application and evaluation of systems within organizations. It prepares students for roles in academia or industry with respect to teaching, development in management, and research.

NJIT master's students who plan to seek admissions to this program are advised to select this area of specialization. Students can earn, as part of this program, an M.S. in Computer Science from NJIT or an M.B.A. in management from Rutgers-Newark. Admissions is open to outstanding students with a bachelor's or master's degree in a wide variety of disciplines.

Full details of the program can be obtained in writing to the Director, Ph.D. in Management Program, Rutgers, The State University of New Jersey, 82 New St., Newark, N.J. 07102. For specific advisement on the specialization in computer information and systems, contact Murray Turoff.

Manufacturing Systems Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Paul G. Ranky
Associate Chairperson: Kevin J. McDermott
Program Director: Kevin McDermott
Professors: Abdel-Malek, Caudill, Hatch, Ranky, Sebastian, Swart, Tricamo, Wolf
Associate Professors: Abdou, Bengu, Bladikas, Chao, Das, Gage, McDermott
Assistant Professor: Jeng
Graduate Advisor: Kevin McDermott (201) 596-3185 (Room 2400 GITC), e-mail mcdermot@admin.njit.edu

Degrees Offered: Master of Science in Manufacturing Systems Engineering

■ MASTER OF SCIENCE IN MANUFACTURING SYSTEMS ENGINEERING

This is an interdisciplinary program of advanced study for individuals with backgrounds in engineering, focusing on efficient production in technology-intensive manufacturing industries.

The manufacturing engineering discipline addresses the ways in which the production of goods and services can be made efficient and effective, while simultaneously achieving quality, cost and productivity goals. The M.S. in Manufacturing Systems Engineering program emphasizes the interrelationships between manufacturing equipment, processes and controls, and their integration into production factories.

The curriculum is computer and multimedia intensive and includes the use and understanding of new technologies such as robotics, programmable logic controllers, microprocessors and computer-integrated manufacturing and their application in automated production, assembly, automated inspection and automated packaging. Focus is on computer-aided design and computer-aided manufacturing. Automation laboratories are used that contain many state-of-the-art devices including several industrial robots, CNC millers, CNC lathes, computer vision systems and a fully automated flexible manufacturing system.

Admission Requirements

Applicants should be graduates of an accredited undergraduate engineering program. Students with degrees in science may also be considered.

Bridge Program—Students who lack appropriate undergraduate preparation for the program are required to make up deficiencies by taking a program of courses that are designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

A minimum of 30 credits is required, including projects or thesis. Students select an area of specialization in consultation with the graduate advisor and must take a set of core, required and elective courses.

Seminar—All students who receive departmental or research-based awards must register each semester for MnE 791 Manufacturing Engineer Seminar.

CORE
9 credits:
MnE 601 Manufacturing Systems
MnE 602 Manufacturing Systems Integration
MnE 603 Management of Manufacturing Systems

REQUIRED
3 credits:
Math 661 Applied Statistics *or* course in mathematics approved by graduate advisor.

PROJECT OR THESIS (required)
6 credits from:
MnE 700 Master's Project I *and*
MnE 702 Master's Project II *or*
MnE 701 Master's Thesis

AREAS OF SPECIALIZATION

The range of possible specializations is broad. Students should consult the director of the program in designing specializations and related degree requirements. Some examples follow:

Automated Production Systems

ELECTIVE
12 credits from:
CIS 500 Introduction to Systems Analysis
CIS 610 Data Structures and Algorithms
CIS 651 Data Communications
CIS 661 Systems Simulation
CIS 673 Software Design and Production Methodology
EE 601 Linear Systems
EE 660 Control Systems I
EE 664 Real-Time Computer Control Systems
EE 683 Computer Network Design and Analysis
EE 686 Instrumentation Systems and Microprocessors
IE 612 Robotic Manufacturing Systems
IE 655 Concurrent Engineering
IE 661 Man-Machine Systems
IE 669 Human Design Factors in Engineering
Math 630 Linear Algebra and Applications
Math 761 Statistical Reliability Theory and Applications
ME 615 Advanced Mechanical Vibrations
ME 625 Introduction to Robotics
ME 632 Instrumentation
ME 633 Dynamics of Machinery
ME 636 Mechanism Design: Analysis and Synthesis
ME 660 Noise Control
MnE 716 Selected Topics in Automated Production Systems
MnE 726 Independent Study in Automated Production Systems

Computer Control of Manufacturing Systems

ELECTIVE
12 credits from:
CIS 651 Data Communications
CIS 653 Microcomputers and Applications
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
EE 601 Linear Systems
EE 660 Control Systems I
EE 664 Real-Time Computer Control Systems
EE 666 Control Systems II
EE 673 Random Signal Analysis I
EE 677 Optimization Techniques
EE 684 Advanced Microprocessor Systems
EE 686 Instrumentation Systems and Microprocessors
EE 766 Stability Theory of Nonlinear Systems
EE 768 Optimal Control Theory
EE 769 Stochastic Estimation and Control
Math 630 Linear Algebra
Math 691 Stochastic Processes with Applications
ME 632 Instrumentation
ME 653 Control of Electro-Mechanical Networks
MnE 719 Selected Topics in Computer Control of Manufacturing Systems
MnE 729 Independent Study in Computer Control of Manufacturing Systems

Manufacturing Computer Systems Analysis and Design

ELECTIVE
12 credits from:
CIS 510 Assembly Language Programming and Principles
CIS 610 Data Structures and Algorithms
CIS 631 Data Management System Design
CIS 651 Data Communications
CIS 653 Microcomputers and Applications
CIS 655 Microcomputer Systems

CIS 657 Principles of Interactive Computer Graphics
CIS 659 Image Processing and Analysis
CIS 661 Systems Simulation
CIS 662 Model Analysis and Simulation
CIS 780 Computer Vision
EE 601 Linear Systems
EE 660 Control Systems I
EE 664 Real-Time Computer Control Systems
EE 666 Control Systems II
EE 677 Optimization Techniques
EE 683 Computer Network Design and Analysis
EE 684 Advanced Microprocessor Systems
EE 686 Instrumentation Systems and Microprocessors
EE 688 Microcontrollers in Instrumentation
EE 766 Stability Theory on Nonlinear Systems
EE 768 Optimal Control Theory
EE 769 Stochastic Estimation and Control
Math 630 Linear Algebra
Math 691 Stochastic Processes with Applications
MnE 715 Selected Topics in Manufacturing Computer System Analysis and Design
MnE 725 Independent Study in Manufacturing Computer Systems Analysis and Design

Manufacturing Management Systems

ELECTIVE
12 credits from:
EM 502 Engineering Cost Analysis
EM 602 Management Science
EM 635 Management of Engineering Research and Development
EM 636 Project Management
EM 660 Financing an Industrial Enterprise
EM 691 Cost Estimating for Capital Projects
EM 693 Managerial Economics
EM 771 Operations Cost and Management Control
HRM 662 Organizational Design and Development
MnE 718 Selected Topics in Manufacturing Management Systems
MnE 728 Independent Study in Manufacturing Management Systems

Systems and Product Design

ELECTIVE
12 credits from:
CE 636 Stability of Structures
CE 736 Finite Element Methods in Structural and Continuum Mechanics
CIS 662 Model Analysis and Simulation
CIS 672 Expert System Methods and Design
EE 660 Control Systems I
EE 664 Real-Time Computer Control Systems
EE 677 Optimization Techniques
EE 683 Computer Network Design and Analysis
IE 612 Robotic Manufacturing Systems
IE 655 Concurrent Engineering
Math 551 Engineering Mathematics
Math 630 Linear Algebra
Math 671 Asymptotic Methods I
Math 691 Stochastic Processes with Applications
ME 615 Advanced Mechanical Vibrations
ME 620 Stress Methods in Mechanical Design
ME 621 Energy Methods in Mechanical Design
ME 622 Finite Element Methods in Mechanical Engineering
ME 625 Introduction to Robotics
ME 630 Analytical Methods in Machine Design
ME 633 Dynamics of Machinery
ME 634 Analysis and Synthesis for Design
ME 635 Computer-Aided Design
ME 636 Mechanism Design: Analysis and Synthesis
ME 653 Control of Electro-Mechanical Networks
ME 675 Mechanics of Fiber Composites
MnE 717 Selected Topics in System and Product Design
MnE 727 Independent Study in System and Product Design

Materials Science and Engineering

(pending approval)

Administered by: Committee for the Interdisciplinary Program in Materials Science and Engineering

Acting Program Director and Graduate Advisor: Ken K. Chin (201) 596-3297 (Room 466 TIE), e-mail chin@admin.njit.edu

Degrees Offered: Master of Science in Materials Science and Engineering; Doctor of Philosophy in Materials Science and Engineering

The master's program is currently offered under the degree designation Master of Science in Engineering Science. The specific degree designations Master of Science and Doctor of Philosophy in Materials Science and Engineering are pending approval.

The interdisciplinary M.S. and Ph.D. in Materials Science and Engineering focus on the properties and applications of modern engineering materials, bridges academic research and industrial development, and serves New Jersey's technology-intensive economy. Three areas of specialization are emphasized: Electronic and Photonic Materials, Polymer and Biomaterials, and Composite and Structural Materials. These degree programs are intended for individuals with a strong background in science and/or engineering.

■ MASTER OF SCIENCE IN MATERIALS SCIENCE AND ENGINEERING

Admission Requirements

Applicants are expected to have an undergraduate degree from an accredited institution. A minimum undergraduate grade point average (GPA) of 3.0 on a 4.0 scale, or equivalent, is normally required for admission. An undergraduate major in physics, chemistry, materials science, or a related engineering discipline is preferred. Graduate Record Examinations (GRE) quantitative scores of 700 or higher are highly desirable. Students from countries where English is not the native language should demonstrate TOEFL scores higher than 550.

Bridge Program—Students who lack appropriate undergraduate preparation for the program are asked to make up deficiencies by taking a program of courses which is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

Candidates must complete a minimum of 30 credits, including 12 credits of required materials science courses and 18 credits in an area of specialization, which are selected in consultation with the graduate advisor.

Seminar—In addition to the minimum 30 degree credits required, all students who receive program or research-based awards must enroll each semester in MtSE 791 Graduate Seminar.

REQUIRED
9 credits:
MtSE 605 Fundamentals of Engineering Materials
MtSE 610 Mechanical Properties of Materials
MtSE 630 Thermodynamics of Materials

3 credits from:
CE 635 Fracture Mechanics of Engineering Materials
Chem 640 Polymer Chemistry
ME 675 Mechanics of Fiber Composites
Phys 687/26:755:687 Physics of Materials

PROJECT OR THESIS
Required of all students receiving program or research-based awards; optional for all others.
3 credits: MtSE 700 Master's Project *or*
6 credits: MtSE 701 Master's Thesis

AREAS OF SPECIALIZATION

The range of possible specialization is broad. Students should consult the graduate advisor in designing the area of specialization and related degree requirements. Three focus areas and suggested courses are listed below.

Electronic and Photonic Materials

18 credits from:

Chem 611 Solid-State Inorganic Chemistry
Chem 626 Chemistry of Contemporary Materials
Chem 662 Chemical Processing of Electronic Materials
EE 623 Fourier Optics
EE 625 Fiber and Integrated Optics
EE 626 Optoelectronics
EE 657 Semiconductor Devices
EE 658 VLSI Design
EE 659 Fabrication Principles of Electronic and Optoelectronic Devices
EE 739 Laser Systems
EE 760 Solid-State Image Sensors
MtSE 615 Composite Materials
MtSE 625 Introduction to Ceramics
MtSE 627 Glass Science and Engineering
MtSE 702 Characterization of Solids
MtSE 737 Transport of Electrons and Phonons in Solids
MtSE 757 Defects in Solids
MtSE 765 Science and Technology of Thin Films
Phys 661/26:755:661 Solid-State Physics
Phys 667/26:755:667 Modern Experimental Techniques for Materials Processing and Characterization
Phys 762/26:755:762 Electronic Structure of Solids
Phys 763/26:755:763 Surface and Interface Physics
Phys 771/26:755:771 Quantum Electronics
Phys 781/26:755:781 Physics of Advanced Semiconductor Devices
Phys 789/26:755:789 Physics of Advanced Semiconductor Device Processing

Polymer and Biomaterials

18 credits from:

BME 569 Quantitative Physiology for Engineers
BME 672 Biomaterials
ChE 627 Introduction to Biomedical Engineering
Chem 540 Introduction to Polymers
Chem 640 Polymer Chemistry
Chem 641 Polymer Properties
Chem 643 Polymer Laboratory I
Chem 645 Polymer Laboratory II
Chem 661 Instrumental Analysis
Chem 673 Biochemistry
EE 667 Systems Studies in Bioengineering
Math 661 Applied Statistics
ME 670 Introduction to Biomechanical Engineering
ME 671 Biomechanics of Human Structure and Motion
ME 675 Mechanics of Fiber Composites
ME 676 Applied Plasticity
ME 678 Engineering Design of Plastic Products
ME 679 Polymer Processing Techniques
ME 680 Polymer Processing Equipment
MtSE 615 Composite Materials
MtSE 625 Introduction to Ceramics
MtSE 702 Characterization of Solids
MtSE 737 Transport of Electrons and Phonons in Solids
MtSE 757 Defects in Solids
MtSE 765 Science and Technology of Thin Films

Courses in metallic biomaterials and polymeric biomaterials offered at the University of Medicine and Dentistry of New Jersey and courses in biosciences offered at Rutgers-Newark may be taken as electives. See the graduate advisor for information about these courses and registration.

Composite and Structural Materials

18 credits from:

Chem 540 Introduction to Polymers
Chem 611 Solid-State Inorganic Chemistry
Chem 624 Modern Organic Chemistry
Chem 654 Corrosion
Chem 655 Electrochemistry: Principles and Applications
Chem 661 Instrumental Analysis
CE 631 Advanced Reinforced Concrete Design
CE 632 Prestressed Concrete Design
CE 634 Structural Dynamics
CE 635 Fracture Mechanics of Engineering Materials
CE 636 Stability of Structures
Math 661 Applied Statistics
Mech 540 Advanced Strength of Materials
Mech 630 Theory of Elasticity
ME 626 Corrosion
ME 675 Mechanics of Fiber Composites
ME 676 Applied Plasticity
ME 678 Engineering Design of Plastic Products
ME 679 Polymer Processing Techniques
ME 680 Polymer Processing Equipment
ME 776 Dynamics of Polymeric Liquids
ME 785 Theory of Deformable Solids in Mechanical Engineering I
ME 786 Theory of Deformable Solids in Mechanical Engineering II
MtSE 615 Composite Materials
MtSE 625 Introduction to Ceramics
MtSE 627 Glass Science and Engineering
MtSE 650 Physical Metallurgy
MtSE 655 Diffusion and Solid State Kinetics
MtSE 702 Characterization of Solids
MtSE 725 Crystallography and Diffraction
MtSE 757 Defects in Solids
Phys 667/26:755:667 Modern Experimental Techniques for Materials Processing and Characterization

■ DOCTOR OF PHILOSOPHY IN MATERIALS SCIENCE AND ENGINEERING

This is a degree program for superior students who wish to do advanced research in an area of materials science and engineering. Current areas of research include electronic and photonic materials, polymer and biomaterials, and composite and structural materials.

Admission Requirements

Applicants are expected to have an appropriate master's degree in materials science or related field, physics, chemistry, or engineering from an accredited institution. Students entering with a master's degree must have at least 3.5 GPA on a 4.0 scale in previous graduate

study. Highly qualified students with bachelor's degrees may be accepted directly into the doctoral program. These students must have at least a 3.5 GPA in undergraduate work.

Degree Requirements

Students with an appropriate master's degree in materials science or related field, physics, chemistry or engineering, are required to complete a minimum of 60 credits beyond the master's degree: 24 credits are course work, 12 of which must be at the 700 level and none at the 500 level, and 12 are materials science and engineering or related courses. A minimum 36 credits of doctoral dissertation research is required. Among the course work, no less than 12 credits are materials science and engineering or related courses. Specific course selection, the area of specialization and dissertation topics are approved by the program advisor on an individual basis.

Students entering with bachelor's degrees are required to complete a minimum of 78 credits: 42 credits are course work and 36 credits are doctoral dissertation research. For the course work, the required courses for the M.S. in Materials Science and Engineering are mandatory; no less than 24 credits must be materials science and engineering or related courses, and no less than 12 credits must be at the 700 level and none at the 500 level. Specific course selection, the area of specialization, and dissertation topics are approved by the program advisor on an individual basis.

REQUIRED

For those entering with a master's degree:
24 credits of course work beyond the master's degree
36 credits of MtSE 790 Doctoral Dissertation and Research
MtSE 791 Graduate Seminar each semester

For those entering with a bachelor's degree:
9 credits:
MtSE 605 Fundamentals of Engineering Materials
MtSE 610 Mechanical Properties of Materials
MtSE 630 Thermodynamics of Solids

3 credits from:
CE 635 Fracture Mechanics of Engineering Materials
Chem 640 Polymer Chemistry
ME 675 Mechanics of Fiber Composites
Phys 687/26:755:687 Physics of Materials

30 credits of course work beyond the master's degree core requirements above
36 credits of MtSE 790 Doctoral Dissertation and Research
MtSE 791 Graduate Seminar: each semester.

Qualifying Examination—All doctoral students are expected to pass a written qualifying examination that tests general academic preparation and competence in materials science and engineering. It must be taken within the first year following admission to the program and passed within two years of admission. The examination is offered at least once a year; a student will be allowed two attempts to pass.

Formation of Dissertation Committee—Within four months of passing the qualifying examination, doctoral students must form a dissertation committee that meets the approval of the graduate program director for materials science and engineering. The committee must include the dissertation advisor, three additional faculty members from the program, and at least one member from outside the program or NJIT. Within one year after passing the qualifying exam, the student is required to present a preliminary research proposal for approval by the dissertation committee.

Dissertation and Defense—An oral presentation and public defense of the doctoral dissertation is required.

Mathematics

Administered by: Department of Mathematics

Chairperson and Foundation Chair: Gregory A. Kriegsmann
Distinguished Professors: Goldberg, Kriegsmann
Professors: Ahluwalia, Andrushkiw, Blackmore, Lacker, D. Levy, Milojevic, Perez, Porter, Stickler, Tavantzis, Voronka
Associate Professors: Bechtold, Bhattacharjee, Booty, Bukiet, Chase, S. Cohen, Dios, Garfield, Kappraff, Katzen, Lieb, Luke, Papageorgiou, Plastock, Sran
Assistant Professors: Berliner, Booth, Bose, Crato, Hile, Michalopoulou, Ray, Siegel, Tilley

Graduate Advisor (NJIT): John Bechtold (201) 596-3489 (Room 610 CUL), e-mail bechtold@admin.njit.edu

Degrees Offered: Master of Science in Applied Mathematics; Doctor of Philosophy in Mathematical Sciences offered jointly with Rutgers-Newark.

Applied mathematics is the application of classical and modern mathematical techniques to the solution of practical problems in the natural sciences and engineering. The applied mathematician develops and analyzes mathematical models of physical phenomena, then collects and interprets data in order to identify relationships, patterns, and the impact of altering one or more variables or modeling assumptions. Many of the courses in the program illustrate how mathematics can be used to predict the behavior of physical phenomena.

The options of the master's in applied mathematics program (analysis, applied mathematics, computational methods and statistics) are designed to serve the needs of students who are interested in pursuing a doctoral degree in mathematics or the physical sciences. The program also serves students with a bachelor's degree who are planning to strengthen their quantitative and analytical skills in preparation for work in industry, commerce, or education as well as practicing engineers and others already employed in industry and commerce who wish to improve their quantitative and analytical skills.

■ MASTER OF SCIENCE IN APPLIED MATHEMATICS

The program is intended for students with a strong interest in applied mathematics and statistics.

Admission Requirements

It is expected that students applying for admission will have an undergraduate education in mathematics, engineering or the sciences.

Bridge Program—Students with baccalaureate degrees in other areas may be required by the department to take an individually-designed program of courses (that may include undergraduate courses) before proceeding to the graduate curriculum. Such courses do not count towards a graduate degree.

Degree Requirements

Candidates select an area of specialization and must complete 30 credits, with at least 24 credits at the 600-level and no more than 6 credits at the 500-level. Specific course requirements depend on the area of specialization. A project or thesis is optional.

The choice of electives is made in consultation with a graduate advisor in the department, and consists of advanced courses in

mathematics or advanced courses offered by other departments such as physics, computer and information science, or one of the engineering departments.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in Math 791 Graduate Seminar.

CORE
15 credits
For all specializations except statistics. The required courses for Statistics are found under that heading.
Math 613 Advanced Applied Mathematics I: Modeling
Math 631 Linear Algebra
Math 645 Analysis I
Math 656 Complex Variables I
Math 689 Advanced Applied Mathematics II: ODEs
Students specializing in Applied Mathematics or Computational Methods may substitute the combination of Math 545 Advanced Calculus I and Math 546 Advanced Calculus II for Math 645 and 3 credits of elective.

PROJECT OR THESIS (optional)
3 credits: Math 700 Master's Project *or*
6 credits: Math 701 Master's Project

AREAS OF SPECIALIZATION

Applied Mathematics

REQUIRED
6 credits:
Math 614 Numerical Methods I
Math 690 Advanced Applied Mathematics III: PDEs

ELECTIVE
9 credits selected with approval of graduate advisor

Computational Methods

REQUIRED
6 credits:
Math 614 Numerical Methods I
Math 712 Numerical Methods II

ELECTIVE
9 credits selected with approval of graduate advisor

Analysis

REQUIRED
9 credits:
Math 730 Applied Algebra
Math 745 Analysis II
Math 756 Complex Variables II

ELECTIVE
6 credits selected with approval of graduate advisor

Statistics

REQUIRED
21 credits:
Math 545 Advanced Calculus I *or*
Math 645 Analysis I
Math 614 Numerical Methods I *or*
Math 631 Linear Algebra
Math 662 Mathematical Statistics I
Math 698 Sampling Theory
Math 699 Design and Analysis of Experiments
Math 707 Advanced Applied Mathematics IV: Special Topics
Math 762 Mathematical Statistics II

ELECTIVE
9 credits selected with approval of graduate advisor

■ DOCTOR OF PHILOSOPHY IN MATHEMATICAL SCIENCES

NJIT Faculty: See listing on page 73.

Rutgers-Newark Faculty
Professor: Gilman
Associate Professors: Feighn, Keys, Levinson, Mosher, Oertel, Randall, Sczech, Sturm
Assistant Professor: Tan

Graduate Program Director: To be appointed. Department of Mathematics and Computer Science, Smith Hall (201) 648-5156

The degree of Doctor of Philosophy in Mathematical Sciences is offered jointly by the Department of Mathematics at NJIT and the Department of Mathematics and Computer Science at Rutgers-Newark. The program has two broadly defined options: applied mathematics, offered by NJIT, and pure mathematics, offered by Rutgers-Newark.

The applied mathematics option emphasizes the applications of mathematical methods to the natural sciences and engineering, including acoustics, electromagnetics, fluid dynamics, manufacturing, biology and medicine. Mathematical modeling, asymptotic analysis, and scientific computing are emphasized. Students are expected to develop a broad range of capabilities both in mathematics and in an area of application. The applied mathematics option is intended to provide preparation for those seeking careers as applied mathematicians in either academia or industry.

The pure mathematics option offers research opportunities in many fields of specialization, including representation theory, graph theory, number theory, low-dimensional topology, Riemann surfaces and Kleinian groups, combinatorial group theory, and 4-manifolds.

Students in either option will be able to and are encouraged to select a program of study that includes several courses in the other option. In this way students can develop the kind of mathematical versatility needed to solve mathematical problems in a world where the line between applied and pure mathematics is becoming increasingly indistinct.

Admission Requirements

Admission to the program is based on a review of the applicant's credentials and interests as expressed in his/her academic transcripts, Graduate Record Examinations scores, letters of recommendation, statement of interests, and TOEFL scores (for students whose native language is not English). Applicants with strong academic records whose abilities and interests complement the research of the faculty are sought. Normally, applicants should have a bachelor's or master's degree in mathematics, an engineering discipline, or a branch of the natural sciences.

Those interested primarily in the Applied Mathematics Option should

apply to NJIT, while students interested in the Pure Mathematics Option should apply to Rutgers-Newark.

Applied Mathematics (NJIT)

Students choosing the applied mathematics option must fulfill the requirements for the doctor of philosophy as specified in this catalog. Specific courses of study are planned in consultation with a faculty advisor and are subject to approval. In general, students are encouraged to take courses both in mathematics and in areas of application.

Seminar—In addition to the minimum degree credits required, all doctoral students must enroll each semester in Math 791 Graduate Seminar.

Qualifying Examination—The qualifying examination for the applied mathematics option consists of three components: analysis, linear algebra/numerical methods, and applied mathematics. Students must achieve a grade of A in each component to pass the qualifying examination. Components may be passed at different times. However, a student may attempt each component at most twice and must pass all three components by the end of the second year in the program. Typically, two opportunities to take each component are provided each year: analysis and linear algebra/numerical methods (September and January), applied mathematics (January and May).

Dissertation Committee—The dissertation committee is an important resource for the doctoral student in the conduct of research for their dissertation. Within six months of passing the qualifying examination a dissertation committee must be formed according to the regulations specified in this catalog.

Dissertation Proposal—Doctoral students must prepare a research proposal for approval by their dissertation committee. The student must offer an oral defense of this proposal before the dissertation committee. The committee determines if the proposal has an appropriate objective, if there is a reasonable plan to reach that objective, and if the student possesses the knowledge and skills needed to carry out the plan. The dissertation proposal is approved only on unanimous consent of the committee members. Approval of the dissertation proposal must precede the defense of the dissertation by no less than six months.

Dissertation Defense—A public oral defense of the dissertation before the dissertation committee is required. All members of the committee must be present for the defense. Success of the defense is determined by a majority vote of the dissertation committee.

Pure Mathematics (Rutgers-Newark)

Students interested in the pure mathematics option complete four core courses, a series of four required courses within the option and 24 credits of advanced elective courses. The advanced electives are chosen in consultation with the advisor, advisory committee, and the graduate program director. For further information, contact the Rutgers-Newark Department of Mathematics and Computer Science.

Qualifying Examination—The qualifying examination for the pure mathematics option consists of three parts, each covering the basic topics in a particular subdiscipline.
Part A Real and Complex Analysis
Part B Algebra
Part C Topology and Geometry

Dissertation—Upon completing the qualifying examination, students are required to complete a minimum of 24 credits of doctoral dissertation research under the direction of a faculty member.

Oral Examination—The student presents a completed dissertation to the thesis committee, which conducts a final oral examination.

Mechanical Engineering

Administered by: Department of Mechanical Engineering

Chairperson: Bernard Koplik
Associate Chairpersons: John Droughton, Rong Chen (graduate)
Sponsored Chair: Ming Leu (manufacturing/productivity)
Jacobus Chair: Nadine Aubry
Professors: Aubry, R. Chen, Cochin, Droughton, Fenster, Geskin, Harnoy, Kirchner, Koplik, Leu, Linden, Wilson
Associate Professors: Dave, Dubrovsky, Fischer, Florio, Ji, Rosato, Sodhi
Assistant Professors: Chu, Narh, Singh
Research Professors: Ugural, Yu
Special Lecturers: Kountouras, Serico, Surjanhata

Graduate Advisor: Rong Chen (201) 596-3327 (Room 205 ME), e-mail chenr@admin.njit.edu

Degrees Offered: Master of Science in Mechanical Engineering; Degree of Engineer; Doctor of Philosophy in Mechanical Engineering

Mechanical engineering is concerned with the design, development, manufacture, and operation of a wide variety of energy conversion and machine systems. The research and education facilities of the department are housed in the 60,000-square-foot Mechanical Engineering Building. Major research laboratories include Particle Technology, Machine Vision and Motion Analysis, Waterjet Machining, Robotics and Intelligent Manufacturing, Bearing Lubrication, and Plastic Processing and Analysis.

■ MASTER OF SCIENCE IN MECHANICAL ENGINEERING

A program for engineering graduates who want advanced professional preparation and further graduate study in mechanical engineering.

Admission Requirements

Applicants are expected to have an accredited undergraduate degree in mechanical engineering or a related field. General admissions requirements for master's programs as described in this catalog apply to applicants to the M.S. in Mechanical Engineering. Sufficient preparation in science and mathematics to complete the course of study is also necessary.

Bridge Program—Students who lack appropriate undergraduate preparation are asked to make up deficiencies by taking a program of courses that is designed in consultation with the graduate advisor. These courses are taken in addition to the degree requirements and may include undergraduate courses.

*Degree Requirements

The program shown below offers numerous areas of specialization, each with its own list of required and elective courses. Once the specialization is chosen, the student consults the graduate advisor to plan and develop an individualized and cohesive sequence of courses that meet program requirements of at least 30 degree credits.

Seminar—In addition to the minimum 30 degree credits required, every student must take a minimum of two semesters of ME 794. Students who receive departmental or research-based awards must enroll each semester in ME 794.

PROJECT OR THESIS

Thesis is required of all students who receive departmental or research-based awards. For all others, a project or thesis is optional.
3 credits: ME 700 Master's Project
6 credits: ME 701 Master's Thesis

AREAS OF SPECIALIZATION

The range of possible specializations is broad. Students should consult with the graduate advisor in designing specialization and related degree requirements. Some example areas of specialization and the ME courses for each are listed on the next page. The number of elective credits for each area of specialization will vary according to the number of required course credits and also if a student enrolls in ME 700 or ME 701. With the approval of the advisor, students may take courses from other departments to enhance areas of specialization.

*Note: Before registering for courses, all students must see the graduate advisor to obtain the latest version of the brochure, "Graduate Programs in Mechanical Engineering."

Biomechanical Engineering

REQUIRED
15 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 622 Finite Element Methods in Mechanical Engineering
ME 635 Computer-Aided Design
ME 671 Biomechanics of Human Structure and Motion

ELECTIVE
9 or 12 or 15 credits from:
ME 670 Introduction to Biomechanical Engineering
BME 669 Quantitative Physiology for Engineers
BME 672 Biomaterials
Other suitable courses to be selected with approval of the graduate advisor.

Particle Technology

REQUIRED
12 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 624 Microlevel Modeling in Particle Technology
ME 717 Selected Topics in Mechanical Engineering I: Experiments and Simulations in Particle Technology

ELECTIVE
12 or 15 or 18 credits:
*ME 524 Introduction to Particle Technology
ME 628 Machine Vision Principles and Applications
Other suitable courses to be selected with approval of the graduate advisor.

Robotics and Controls

REQUIRED
12 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 625 Introduction to Robotics
ME 655 Introduction to Modern Control Methods

ELECTIVE
12 or 15 or 18 credits from:
ME 628 Machine Vision Principles and Applications
ME 633 Dynamics of Machinery
ME 635 Computer-Aided Design
ME 735 Advanced Topics in Robotics
ME 755 Adaptive Control Systems
Other suitable courses to be selected with approval of the graduate advisor.

*pending

Design and Mechanisms

REQUIRED
12 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 621 Energy Methods in Mechanical Design
ME 637 Kinematics of Spatial Mechanisms

ELECTIVE
12 or 15 or 18 credits:
ME 615 Advanced Mechanical Vibrations
ME 630 Analytical Methods in Machine Design
ME 633 Dynamics of Machinery
ME 635 Computer-Aided Design
ME 636 Mechanism Design: Analysis and Synthesis
ME 736 Advanced Mechanism Design
Other suitable courses to be selected with approval of the graduate advisor.

CAD/CAM

REQUIRED
15 credits:
ME 616 Matrix Methods in Mechanical Engineering
ME 620 Stress Methods in Mechanical Design
ME 622 Finite Element Methods in Mechanical Engineering
ME 635 Computer-Aided Design
ME 638 Computer-Aided Machining

ELECTIVE
9 or 12 or 15 credits:
ME 625 Introduction to Robotics
ME 628 Machine Vision Principles and Applications
ME 630 Analytical Methods in Machine Design
ME 734 Analysis and Synthesis for Design
ME 736 Advanced Mechanism Design
Other suitable courses to be selected with approval of the graduate advisor.

Energy Systems

REQUIRED
12 credits:
ME 607 Advanced Thermodynamics
ME 610 Applied Heat Transfer
ME 611 Dynamics of Incompressible Fluids
ME 616 Matrix Methods in Mechanical Engineering

ELECTIVE
12 or 15 or 18 credits from:
ME 641 Refrigeration and Air Conditioning
ME 644 Building Environmental Control Principles
ME 711 Convection Heat Transfer
ME 712 Mechanics of Viscous Fluids
Other suitable courses to be selected with approval of the graduate advisor.

Materials and Processing

REQUIRED
12 credits:
ME 610 Applied Heat Transfer
ME 616 Matrix Methods in Mechanical Engineering
ME 675 Mechanics of Fiber Composites
ME 678 Engineering Design of Plastic Products

ELECTIVE
12 or 15 or 18 credits from:
ME 624 Microlevel Modeling in Particle Technology
ME 680 Polymer Processing Equipment
ME 776 Dynamics of Polymeric Liquids
MtSE 605 Fundamentals of Engineering Materials
MtSE 610 Mechanical Properties of Materials
MtSE 615 Composite Materials
MtSE 650 Physical Metallurgy
Other suitable courses to be selected with approval of the graduate advisor.

■ DOCTOR OF PHILOSOPHY IN MECHANICAL ENGINEERING

This is a program for superior students with master's degrees in mechanical engineering or allied fields who wish to do advanced research in an area of mechanical engineering. In exceptional circumstances, highly qualified students with bachelor's degrees in mechanical engineering may be accepted directly into the doctoral program.

Admission Requirements

Applicants should have a master's degree from an accredited institution, and have successfully taken courses in applied mathematics and engineering sciences. Students who lack an appropriate background will be required to take additional courses before gaining admission to the program. These courses are prescribed by the department on an individual basis and may not be applied as degree credit.

*Degree Requirements

Specific degree requirements and dissertation topics are approved by the department on an individual basis. Before being permitted to register for dissertation research, students must complete courses specified by the department, pass qualifying examinations and demonstrate that there are facilities and a faculty member available to supervise the research.

Should dissertation research not be completed within the normal 36 credits of ME 790, students must register for a minimum of 3 credits per semester until it is completed and accepted.

REQUIRED

24 credits of course work beyond the master's degree

ME 794 Mechanical Engineering Colloquium; required every semester for doctoral students

36 credits of ME 790 Doctoral Dissertation and Research

Qualifying Examination—Once admitted to the program, candidates are expected to pass a three-part written qualifying examination. It is given at least once a year. Students must apply in writing to the graduate advisor for permission to take qualifying examinations. From the time of formal admission into the program, the exam must be taken by the second time it is offered, except students with departmental or research-based assistantships must take it the first time it is offered. At the discretion of the department, an additional oral examination may be required.

Part I—Applied Mathematics (ordinary and partial differential equations, vector analysis, complex variables, numerical methods, and boundary value problems, etc.)

Part II—Two parts selected from engineering mechanics, fluid mechanics, heat transfer, stress analysis, system dynamics, thermodynamics.

Oral Examination—An oral defense of the dissertation is required after submission of the final document to the department for approval.

■ DEGREE OF ENGINEER

This program is for the practicing professional mechanical engineer. It emphasizes the application of new scientific knowledge to the engineer's practice.

Admission Requirements

A master's degree in mechanical engineering; and at least three years of professional experience as a mechanical engineer are required. A GPA of at least 3.0 in previous graduate studies is also required for admission. In addition, candidates must register for two semesters of ME 794 Mechanical Engineering Colloquium.

*Degree Requirements

Students accepted for the Degree of Engineer program must complete a total of 36 credits, including 24 credits of course work and a 12-credit professional design project.

*Note: Before registering for courses, all students must see the graduate advisor to obtain the latest version of the brochure, "Graduate Programs in Mechanical Engineering."

Occupational Safety and Health Engineering

Administered by: Department of Industrial and Manufacturing Engineering

Chairperson: Paul G. Ranky
Associate Chairperson: Kevin McDermott
Program Director and Graduate Advisor: Howard Gage (201) 596-3653 (Room 2509 GITC), e-mail gageh@admin.njit.edu
Faculty: Gage, Jeng

Degree Offered: Master of Science in Occupational Safety and Health Engineering

■ MASTER OF SCIENCE IN OCCUPATIONAL SAFETY AND HEALTH ENGINEERING

This master's program trains engineers in the specialty of occupational safety and health. Upon graduation, students are able to assume both technical and managerial responsibilities borne by safety professionals.

The curriculum has been designed in accordance with the National Institute for Occupational Safety and Health (NIOSH), which sponsors the program. Through course work and research, individuals are exposed to all of the principal areas of concern to the entry-level safety professional, including how technology and hazardous materials affect the safety of the workplace.

NJIT's program is just one of a handful offered in the United States and the only master's level program in New Jersey. NIOSH offers a limited number of stipends and tuition remission grants to qualified students.

Admission Requirements

Applicants normally are practicing engineers with an accredited bachelor's degree in any field of engineering.

Bridge Program—Students who lack an appropriate background are asked to make up deficiencies by taking a program of courses that is designed in consultation with graduate advisors. These courses are taken in addition to the degree requirements and may include undergraduate courses.

Degree Requirements

A minimum of 36 credits is required.

Seminar—In addition to the minimum 36 degree credits required, all students who receive departmental or research-based awards must enroll each semester in IE 791 Graduate Seminar.

REQUIRED

18 credits from:

IE 614 Safety Engineering Methods
IE 615 Industrial Hygiene and Occupational Health
IE 661 Man-Machine Systems
IE 677 Applied Statistics and Epidemiology for Hazardous Analysis
IE 685 Systems Safety
EM 633 Legal Aspects of Health and Safety

THESIS

Required of NIOSH trainees; optional for all others.
6 credits: IE 701 Master's Thesis

ELECTIVE

12 to 18 credits from:

BME 669 Quantitative Physiology for Engineers
ChE 671 Chemical Process Safety
EvSc 614 Quantitative Environmental Risk Assessment
EvSc 616 Toxicology for Engineers and Scientists
IE 608 Product Liability Control
IE 670 Industrial Work Physiology
IE 675 Safety in Facility and Product Design
IE 725 Independent Research
ME 660 Noise Control
ME 670 Introduction to Biomechanical Engineering

Power Engineering (pending approval)

Administered by: Department of Electrical and Computer Engineering

Program Director: Edwin Cohen
Graduate Advisors: faculty assigned from Newark College of Engineering, depending on student's interest

Degree Offered: Master of Science in Power Engineering

Approval of the M.S. in Power Engineering is pending and is expected to be instituted by January 1997.

■ MASTER OF SCIENCE IN POWER ENGINEERING

Large and plentiful supplies of energy are at the foundation of modern industrial societies. It makes possible industrial and economic activities on a very large scale, enabling people to be more productive, enhancing their well-being and quality of life in the process. Energy, however, is rarely used at its source, such as a coal mine, oil well, or river. It has to be transported to the location of use or, most of the time, converted to another form before being used. Electrical energy, for example, is the most often converted power because it affords tremendous flexibility in transportation (transmission) and economical utilization. This characteristic is the reason for building large power plants and stringing thousands of miles of transmission lines for distribution to users. Whether electric, gas or water, these industries support their own specialized workforces, including engineers and other technical professionals who engage in an array of tasks in field work, plant operation, management, and government and corporate relations.

Because the power industry is multifaceted, its engineers come from a variety of academic engineering disciplines such as electrical, mechanical, civil, industrial or chemical. Engineers in the power industries interact closely with other engineers as well as with non-engineering professionals.

The M.S. in Power Engineering is designed for engineers already in the power industries, engineers seeking to enter the field, and other professionals in the power industry who desire a relevant master's degree. This interdisciplinary program offers a wide selection of courses from the Newark College of Engineering and the School of Industrial Management in order to provide training and information necessary to meet the demands of unique work environments—an area not covered by traditional engineering discipline graduate programs.

The individual is teamed with a graduate faculty advisor appointed on the basis of background and interests immediately after admission. A course of study is tailored to meet the student's needs and interests. In some cases, the faculty advisor may recommend a bridge program to enable the individual to proceed with the graduate plan of study.

Professional and Technical Communication

Administered by: Department of Humanities and Social Sciences

Acting Chairperson: Norbert Elliot
Associate Chairperson: Richard Quinn
Distinguished Professor: Opie
Professors: Elliot, Lynch
Associate Professors: Steffen-Fluhr, Stiller
Assistant Professors: Coppola, Hilt, Hodge, Kimmelman
Special Lecturers: Fleischer, R. Friedman, King, Simmons
Graduate Advisor: Nancy Coppola (201) 596-3454 (501 CUL); e-mail: coppola@admin.njit.edu

Degree Offered: Master of Science in Professional and Technical Communication

■ MASTER OF SCIENCE IN PROFESSIONAL AND TECHNICAL COMMUNICATION

This program is designed to prepare students for careers in the highly skilled field of technical communication. In a scholarly and professional manner, students develop abilities in writing, research, editing, collaboration, and visual design. Students also acquire an understanding of new communication technologies and media in the program's modern computer laboratory.

Admission Requirements

Students must have an undergraduate degree in a field of science, computer science or engineering, or have an undergraduate degree in another area with experience or strong interest in science and technology. Undergraduate transcripts must show at least a 3.0 GPA overall and a 3.0 GPA in communication courses. A portfolio with samples of the applicant's writing from college and/or work as well as Graduate Record Examinations (GRE) scores are required.

Certificate Program—A 12-credit graduate certificate in Practice of Technical Communications is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu.

Degree Requirements

Students must complete a minimum of 30 credits: 12 credits of core courses, 12 credits of elective courses, and 6 credits from a master's thesis or the combination of a master's project and one independent study course related to the project. The elective courses allow students to specialize in selected areas of technical communication. The thesis or project allows students to demonstrate the ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of that work.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll in Eng 791 Graduate Seminar each semester that it is offered.

CORE

12 credits:

Eng 601 Advanced Professional and Technical Communication
Eng 603 Cultural and Technological Change
Eng 604 Communication Theory
Eng 605 Document Design and Desktop Publishing

THESIS OR PROJECT

6 credits from either:

{ Eng 701 Thesis in Professional and Technical Communication *or*
{ Eng 700 Project in Professional and Technical Communication *and*
Eng 725 Independent Study in Professional and Technical Communication

ELECTIVE

12 credits from:

Eng 611 Research Methods in Professional and Technical Communication
Eng 613 Multimedia Presentations
Eng 620 Proposal Writing
Eng 622 Collaborative and Interpersonal Communication
Eng 624 Professional and Technical Editing
Eng 725 Independent Study in Professional and Technical Communication

These elective courses are being developed and will appear in Registration Materials:

Advanced Graphics
Documentation: Theory and Practice
Hypertext and Hypermedia
Special Topics in Communication (including legal, medical, or environmental writing)
Teaching Technical Writing
Technical and Scientific Writing for Publication

Telecommunications (pending approval)

Offered by: Department of Computer and Information Science and Department of Electrical and Computer Engineering

Directors and Chairpersons: ECE—Richard A. Haddad (201) 596-3516; CIS—Peter Ng (201) 596-3387

Faculty: see Computer and Information Science, Electrical and Computer Engineering, and Management in this catalog

Graduate Advisors: CIS—James McHugh (201) 596-3394, e-mail mchugh@admin.njit.edu; Dennis Karvelas (201) 596-2987, e-mail karvelas@hertz.njit.edu.; ECE—Nirwan Ansari (201) 596-3670, e-mail ansarin@admin.njit.edu; Zoran Siveski (201) 596-5710, e-mail siveski@admin.njit.edu

Degree Offered: Master of Science in Telecommunications

■ MASTER OF SCIENCE IN TELECOMMUNICATIONS

Telecommunications is one of the most rapidly growing fields in engineering. Telecommunications specialization also is rapidly becoming necessary in such diverse fields as banking, reservation systems, office information systems, corporate networks, the Internet, etc. Recent challenges like gigabit optical networks, multimedia communications, and wireless network access, make the future of the field very exciting. The objective of this program is to educate individuals in one or more of these telecommunication specializations.

Admission Requirements

Students can apply for admission to the program through either the Department of Computer and Information Science or the Department of Electrical and Computer Engineering. All applicants must submit scores on the Graduate Record Examinations (GRE) verbal, quantitative, and analytical aptitude tests. Applicants with an undergraduate degree in either computer science, computer engineering or electrical engineering from an accredited institution are expected to have a GPA of at least 3.0. It is expected that these students have taken CIS 333, EE 321 and EE 333 (or their equivalent). Otherwise, these must be taken prior to enrolling in graduate-level courses for which they serve as prerequisites. Applicants having degrees in other fields will be considered for admission on an individual basis. These students may make up deficiencies by completing a bridge program.

Bridge Program—The curriculum for the M.S. in Telecommunications requires a basic knowledge of computer fundamentals such as programming, data structures, computer architecture, signals and systems, and basic communication systems. Bridge courses do not count toward the degree. Completion of the preparatory courses with a 3.0 cumulative grade point average or better is required for transfer to matriculated status. The bridge courses are selected from the following depending on individual background. See the undergraduate catalog for descriptions.

CIS 251	Computer Organization
CIS 332	Principles of Operating Systems
CIS 333	Introduction to UNIX Operating Systems
CIS 505	Programming, Data Structures, and Algorithms
CoE 353	Advanced Computer Architecture
EE 321	Random Signals and Noise
EE 333	Circuits and Systems III
EE 352	Microprocessors
EE 481	Communications Systems

Graduate Certificate Program—A 12-credit graduate certificate in Telecommunications Networking is available as a step toward this degree. See "Graduate Certificates" in this catalog. For further information about extension programs and graduate certificates, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu.

Degree Requirements

Candidates must complete a minimum of 30 credits, with a minimum overall average grade point average (GPA) of 3.0. In addition, a minimum cumulative 3.0 GPA is required in the six core courses. Students with an exceptionally strong telecommunications background may be allowed to replace required courses with advanced electives. Permission of the graduate advisor from the Department of Computer and Information Science or the Department of Electrical and Computer Engineering is required. Students must complete 12 credits in an area of specialization, selected in consultation with a graduate advisor.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in CIS 710 Computer Science Seminar or EE 791 Graduate Seminar.

CORE

18 credits:

CIS 630	Operating System Design
CIS 652	Computer Networks-Architectures Protocols and Standards *or*
EE 683	Computer Network Design and Analysis
CIS 656	Internetworking and Higher Layer Protocols
EE 642	Communication Systems I
EE 644	Introduction to Wireless and Personal Communication Systems
EE 673	Random Signal Analysis I

ELECTIVE

12 credits, to be used in the area of specialization:

CIS 604	Client/Server Computing
CIS 631	Data Management System Design
CIS 633	Distributed Systems
CIS 637	Real-Time Systems
CIS 650	Computer Architecture *or*
CoE 651	Computer Systems Architecture *or*
EE 690	Computer Systems Architecture
CIS 654	Telecommunication Networks Performance Analysis
CIS 658	Multimedia Systems *or*
EE 649	Compression in Multimedia Engineering
CIS 665	Algorithmic Graph Theory
CIS 696	Network Management and Security *or*
EE 638	Network Management and Security
CIS 697	Principles of Broadband ISDN and ATM *or*
EE 639	Principles of Broadband ISDN and ATM
CIS 752	Communication Protocol Synthesis and Analysis
CoE 685	Network Interface Design
EE 646	Introduction to Data Communications
EE 742	Communication Systems II
EE 755	Advanced Topics in Digital Communication
EE 757	Wireless Communications
EE 783	Computer Communication Networks
EE 785	Parallel Processing Systems *or*
CIS 668	Parallel Algorithms
MIS 635	Management of Telecommunications
*MIS 636	Telecommunications: Policies and Regulations

PROJECT OR THESIS (optional)

3 credits:

CIS 700	Master's Project *or*
EE 700	Master's Project

or

6 credits:

CIS 701	Master's Thesis *or*
EE 701	Master's Thesis

*pending

AREAS OF SPECIALIZATION
The following are suggested areas of specialization. Students may develop an individual area of specialization in consultation with a graduate advisor.

Management and Administration

CIS 696 Network Management and Security *or*
EE 638 Network Management and Security
MIS 635 Management of Telecommunications
*MIS 636 Telecommunications: Policies and Regulations
and one additional course

Communication Systems

CIS 697 Principles of Broadband ISDN and ATM *or*
EE 639 Principles of Broadband ISDN and ATM
CoE 685 Network Interface Design
EE 649 Compression in Multimedia Engineering *or*
CIS 658 Multimedia Systems
EE 742 Communications Systems II
EE 755 Advanced Topics in Digital Communication
EE 757 Wireless Communications

Networking

CIS 604 Client/Server Computing
CIS 633 Distributed Systems
CIS 637 Real-Time Systems
CIS 654 Telecommunication Networks Performance Analysis
CIS 697 Principles of Broadband ISDN and ATM *or*
EE 639 Principles of Broadband ISDN and ATM
CIS 650 Computer Architecture *or*
CoE 651 Computer Systems Architecture *or*
EE 690 Computer Systems Architecture
CIS 665 Algorithmic Graph Theory
CIS 696 Network Management and Security *or*
EE 638 Network Management and Security
EE 783 Computer Communication Networks

Information

CIS 604 Client/Server Computing
CIS 631 Data Management System Design
CIS 658 Multimedia Systems *or*
EE 649 Compression in Multimedia Engineering
CIS 696 Network Management and Security *or*
EE 638 Network Management and Security

*pending

Transportation

Administered by: Executive Committee for the Interdisciplinary Program in Transportation

Program Director: Louis Pignataro, e-mail pignataro@admin.njit.edu

Graduate Advisors: Athanassios Bladikas (201) 596-3649 (287 TIE)
Louis Pignataro (201) 596-3355 (287 TIE)

Degrees Offered: Master of Science in Transportation; Doctor of Philosophy in Transportation

The primary objective of the program is to provide knowledge and skills to prepare students to be transportation planners, engineers, and managers who can plan effectively, design optimally, operate efficiently, and manage skillfully transportation systems that are capable of satisfying the needs of society.

Transportation plays a vital role in the functioning of our society by providing for the mobility of people, goods and services. It enables people to access job markets and participate in recreational, cultural, educational and social activities. It adds value to products by moving them from their origin to the place where they are demanded in time for their use. In addition, transportation generates major economic impacts, both as a consumer of resources and as a supplier of jobs.

The transportation program is a major resource to service the personnel needs of transportation organizations in both the public and private sectors. The program will provide opportunities for students to engage in research on all forms of transportation, including all phases of activities concerned with the movement of people and goods, and the provision of services.

The Institute for Transportation provides an excellent opportunity for interaction between faculty, research staff and students.

Transportation professionals must not only be able to meet the technological challenges of new systems, they must also be capable of fitting these systems into the social, economic, and physical environments in such a manner that the quality of life will be improved for all. The program is structured so as to educate professionals who are capable of maximizing the possibility of developing transportation systems which can satisfy various, and sometimes competing, demands and objectives.

An efficient transportation system makes near and far places safely accessible to individuals and reduces the final cost of goods to consumers. Transportation functions in a very complex environment which, at the end of the 20th Century, is characterized by constant change in the technological, regulatory and legal frameworks. The Institute for Transportation continuously influences those changes through its well-known academic programs and research activities.

■ MASTER OF SCIENCE IN TRANSPORTATION

A program for students from diverse educational backgrounds with a variety of career goals that prepares them for careers in designing, planning, operating, maintaining and managing urban and rural transportation systems. The master's degree is a valued professional credential for men and women engaged in the transportation field.

Off-Campus Programs—At the New Jersey Department of Transportation (DOT), in Trenton, NJIT offers sufficient courses to fulfill all degree requirements. All courses are taught by NJIT faculty and are open to non-DOT employees. For further information about extension programs, call the Executive Director, Division of Continuing Professional Education, 1 (800) 624-9850 or (201) 596-3060; e-mail: cpe@njit.edu.

Admission Requirements

Applicants should have a bachelor's degree from an accredited institution with some undergraduate background in economics, mathematics, probability and statistics, and computers.

Bridge Program—Students who lack an appropriate background are asked to make up deficiencies by taking a program of courses designed in consultation with graduate advisors. These courses are

taken in addition to the degree requirements. See the undergraduate catalog for descriptions of 100- to 400-level courses.

Students may be required to take or demonstrate that they already have taken courses equivalent to the following:

CIS 101 Computer Programming and Problem Solving
Math 105 Probability and Statistics
Math 309 Mathematical Analysis for Technology
Econ 265 Microeconomics

Degree Requirements

Students must select one area of specialization and take a minimum of 30 credits including a thesis or project. Tran 701 Master's Thesis and Tran 791 Doctoral Seminar are required for all students who receive departmental or research-based awards. Students who demonstrate neither an undergraduate course in transportation nor professional work experience in the field may be required to register for CE 350 Transportation Engineering. This course cannot be applied toward the master's degree.

Three general areas of specialization are available. While they share a common methodological core, each is designed to suit various interests:

Transportation Engineering focuses on traffic engineering, physical design and operational aspects of transportation systems. This area is best suited for students with an undergraduate engineering degree.

Transportation Planning emphasizes the analysis and planning aspects, in particular the integration of transportation systems with urban and regional considerations such as economics, land use, and the environment.

Advanced Transportation Systems and Technologies emphasizes the use of emerging technologies such as intelligent transportation systems in planning, design and operations of multi- and inter-modal transportation systems.

Seminar—In addition to the minimum 30 degree credits required, all students who receive departmental or research-based awards must enroll each semester in Tran 792 Seminar.

CORE

9 credits:

Tran 603 Introduction to Urban Transportation Planning
Tran 610 Transportation Economics *or*
Econ 565 Managerial Economics
Tran 650 Urban Systems Engineering *or*
EM 602 Management Science

PROJECT OR THESIS

Those receiving departmental or research-based awards must complete a master's thesis. All others may choose either a master's project or a master's thesis.

3 to 6 credits:

Tran 700 Master's Project
Tran 701 Master's Thesis

AREAS OF SPECIALIZATION

Additional courses for all Areas of Specialization as approved by graduate advisor. A maximum of 6 credits may be taken from the 500-level courses for the Master of Science.

Transportation Engineering

REQUIRED

9 credits:

Tran 615 Traffic Studies and Capacity
Tran 625 Public Transportation Operations and Technology
Tran 752 Traffic Control

ELECTIVE

6 to 9 credits from:

Tran 552 Geometric Design of Transportation Facilities
Tran 553 Design and Construction of Asphalt Pavements
Tran 602 Geographic Information Systems
Tran 608 Behavioral Issues in Transportation Studies
Tran 653 Traffic Safety
Tran 659 Flexible and Rigid Pavements
Tran 753 Airport Design and Planning
Tran 754 Port Design and Planning
Tran 755 Intelligent Transportation Systems
Tran 760 Urban Transportation Networks
CE 611 Project Planning and Control
EM 691 Cost Estimating for Capital Projects
EnE 671 Environmental Impact Analysis
HRM 601 Organizational Behavior
IE 651 Industrial Simulation
ME 635 Computer-Aided Design
Mgmt 692 Business Strategy
MIS 648 Decision Support Systems
Mktg 632 Strategic Marketing Management

Transportation Planning

REQUIRED

9 credits:

Tran 670 Transportation Demand Management
Tran 625 Public Transportation Operations and Technology *or*
Tran 705 Mass Transportation Systems
Tran 765 Multi-Modal Freight Transportation Systems Analysis

ELECTIVE

6 to 9 credits from:

Tran 602 Geographic Information Systems
Tran 604 Public and Private Financing of Urban Areas
Tran 608 Behavioral Issues in Transportation Studies
Tran 615 Traffic Studies and Capacity
Tran 653 Traffic Safety
Tran 655 Land-Use Planning
Tran 720 Discrete Choice Modeling for Travel Demand Forecasting
Tran 740 Management of Transportation Carriers
Tran 753 Airport Design and Planning
Tran 755 Intelligent Transportation Systems
Tran 760 Urban Transportation Networks
CE 611 Project Planning and Control
EnE 671 Environmental Impact Analysis
Fin 630 Applied Business Econometrics
HRM 601 Organizational Behavior
HRM 606 Human Resource Management
HRM 662 Organizational Diagnosis and Development
Mgmt 691 Legal and Ethical Issues
Mgmt 692 Business Strategy
MIS 620 Computing Concepts for Managers
Mktg 632 Strategic Marketing Management

ELECTIVE

3 to 6 credits from:

Tran 602 Geographic Information Systems
Tran 604 Public and Private Financing of Urban Areas
Tran 615 Traffic Studies and Capacity
Tran 625 Public Transportation Operations and Technology
Tran 653 Traffic Safety
Tran 670 Transportation Demand Management
Tran 705 Mass Transportation Systems
Tran 720 Discrete Choice Modeling for Travel Demand Forecasting
Tran 740 Management of Transportation Carriers

Tran 760 Urban Transportation Networks
EM 636 Project Management
EnE 671 Environmental Impact Analysis
HRM 606 Human Resource Management
HRM 662 Organizational Diagnosis and Development
IE 606 Maintainability Engineering
MIS 620 Computing Concepts for Managers

Advanced Transportation Systems and Technologies

REQUIRED
9 credits:
Tran 615 Traffic Studies and Capacity
Tran 755 Intelligent Transportation Systems
Tran 765 Multi-Modal Freight Transportation Systems Analysis

ELECTIVE
6 to 9 credits from:
Tran 602 Geographic Information Systems
Tran 608 Behavioral Issues in Transportation Studies
Tran 625 Public Transportation Operations and Technology
Tran 670 Transportation Demand Management
Tran 752 Traffic Control
Tran 760 Urban Transportation Networks
Tran 765 Multi-Modal Freight Transportation Systems Analysis
CIS 610 Data Structures and Algorithms
CIS 651 Data Communication
CIS 661 System Simulation
EE 609 Artificial Neural Networks
EE 642 Communication Systems
EM 714 Multicriteria Decision Making
EnE 671 Environmental Impact Analysis
IE 624 Heuristic Methods
IE 642 Network Flows and Applications
IE 644 Application of Stochastic Modeling in Systems Control
IE 651 Industrial Simulation
IE 705 Mathematical Programming in Management Science
IE 706 A Queueing Approach to Performance Evaluation
HRM 601 Organizational Behavior
ME 635 Computer-Aided Design
Mgmt 692 Business Strategy
MIS 648 Decision Support Systems
Mktg 632 Strategic Marketing Management
Mktg 636 Product Strategy and Management
Mktg 640 Industrial Marketing Management

■ DOCTOR OF PHILOSOPHY IN TRANSPORTATION

The doctoral program is for exceptionally well-qualified students who are mature in scholarship and purpose. It offers a well-balanced mixture of theoretical studies and experimental research. A student must demonstrate creative thinking, self-motivation, and ability to do independent research. In their research, students are expected to deal with complex issues, effectively formulate difficult problems, devise new methodology, and achieve new and exceptional results. The NJIT faculty and students are committed to excellence in research of timely topics, the results of which are expected to push new frontiers in science and technology.

Admission Requirements

Students should have adequate preparation in mathematical and other analytical techniques, and substantial knowledge of the ideas and techniques of synthesis. A thorough understanding of the social and economic factors intrinsic to the functioning and development of transport in urban areas also is necessary. It is expected that students will have earned a minimum GPA of 3.5 in a master's degree program in engineering, planning, or business administration from an accredited university. Outstanding students with baccalaureate degrees also may be accepted. All applicants must take the Graduate Record Examinations (GRE). Full-time study is preferred for doctoral studies.

Degree Requirements

Requirements consist of a minimum of 54 credits of course work beyond the bachelor's degree, including at least 12 credits of 700-level courses, passage of a qualifying examination, a minimum of 36 credits of Tran 790 Doctoral Dissertation and Research, and Tran 791 Doctoral Seminar. Independent original research must be conducted by the candidate in a specific area of transportation. Dissertation work must be of publishable quality.

A program committee must approve a dissertation topic and a faculty member, approved by the program, must be available to supervise the dissertation research. An oral defense of the dissertation is required after a program committee accepts the written document.

Qualifying Examination—All doctoral students must pass a doctoral qualifying examination. To prepare adequately for the examination, students should take appropriate course work in transportation engineering, transportation planning, and transportation administration, as well as other related subjects.

The examination has four parts: the first three are written, and the fourth is oral. The oral part is given after the written parts are evaluated.
Part I Analytical Techniques
Part II Transportation Facilities and Operations
Part III Transportation Planning and Administration
Part IV Oral (includes a field problem)

Graduate Certificates

Administered by: Division of Continuing Professional Education

Executive Director: Gale Tenen Spak (201) 596-8540

Graduate Certificates Offered: Construction Management; Continuous Process Improvement; Environmental Infrastructure and Management; Environmental Site Remediation; Geographic Information System and Environmental Problems; Health Care Information Systems; Object-Oriented Design; Practice of Technical Communications; Programming Environment Tools; Project Management; Telecommunications Networking

Note: Because they are employment-driven, the particular graduate certificates offered in any given year change. See the Continuing Professional Education (CPE) Catalog for current listings.

Students study through electronic means or attend one or two, 3-hour class(es) per week in a lock-step sequence on weeknights and Saturdays at NJIT's University Heights campus or at off-campus, extension locations.

The Graduate Certificate program is designed to facilitate the return to formal advanced education by busy adult professionals. To start, each Graduate Certificate is in a professional field externally validated as "fast growing" with employment opportunities through the year 2005. Second, critical to the conduct of each Graduate Certificate is the philosophy that NJIT course work can proceed quickly in one calendar year and in tandem with other endeavors of an equally demanding nature such as full-time employment and family/childcare responsibilities.

Certificates may be completed in one calendar year by attending designated or lock-step courses in fall, spring and summer semesters. To accomplish this, typically students who start their studies in a fall semester register for one course in the fall, two courses in the spring and one course in the summer. Students who start in a spring semester register for one course each in the spring and summer; and two in the following fall. (Should students' outside pursuits or constraints prevent adherence to this pacing, it may be possible either to accelerate the pacing or to register for missed courses at a later time, since new iterations of the Certificate Program form twice a year in fall and spring semesters.)

Students can complete some Graduate Certificates in whole and others in part through classes conducted via electronic communications that demand equal effort but which do not require formal classroom attendance. More details concerning the electronic classroom are furnished in the Continuing Professional Education Catalog.

Academic Standards

Whether attending with matriculated NJIT graduate students on the NJIT campus, at extension sites or in electronic courses, participants in the Certificate Program are expected to comply with all rules and regulations governing NJIT graduate study as set forth in this catalog.

Admission Requirements

Documented by transcript(s), students must possess, at minimum, an undergraduate degree from an accredited college or university with a grade point average that meets NJIT academic department standards for regular admission as a M.S. degree candidate.

Students must submit an application form for the certificate program in the non-degree (non-matriculated) NJIT admission classification. Application forms are available from the Division of Continuing Professional Education, in the CPE Catalog, and on-line: http://www.njit.edu/cpe.

At the determination of academic department chairs or designees, completion of bridge course(s) may be required to facilitate the student's academic performance.

Students attending NJIT on a non-matriculated basis are limited to enrolling in no more than three graduate courses. As a special feature of the Graduate Certificate Program, students in good standing and after completing 9 certificate credits will be granted automatic waivers by the Office of Graduate Studies for the purpose of completing the graduate certificate without change in admission classification.

It is anticipated that some certificate recipients may desire to continue their studies to a corresponding master's degree. Regular university procedures and policies will apply to those interested in making such a progression.

Certificate Requirements

A student must complete 12 graduate credits in the four pre-selected courses that define the certificate, and maintain a 3.0 grade point average. In consultation with a graduate advisor, a student may substitute and receive credit toward an NJIT certificate for up to two courses completed at another institution. The graduate certificate programs, required courses and corresponding related master's degrees are listed below.

Construction Management

Relates to M.S. in Civil Engineering and M.S. in Engineering Management

CE 610 Construction Management
CE 616 Construction Cost Estimating
EM 632 Legal Aspects in Construction *or*
IE 653 Facility Maintenance
EM 637 Project Control

Continuous Process Improvement

Relates to M.S. in Engineering Management

IE 604 Advanced Engineering Statistics
IE 672 Industrial Quality Control
IE 673 Total Quality Management
Mgmt 650 Leadership in Total Quality Management

Environmental Infrastructure and Management

Relates to M.S. in Environmental Policy Studies; in part to M.S. in Management

Acct 615 Concepts of Strategic Cost Analysis
EM 631 Legal Aspects in Environmental Engineering
EPS 612 Introduction to Environmental Policy Studies
EvSc 614 Quantitative Environmental Risk Assessment

Environmental Site Remediation

Relates to M.S. in Environmental Engineering and M.S. in Environmental Science

EM 631 Legal Aspects in Environmental Engineering
EnE 560 Chemistry for Environmental Engineers *or*
EvSc 610 Environmental Chemical Science
EnE 662 Site Remediation
EvSc 614 Quantitative Environmental Risk Assessment

Geographic Information System and Environmental Problems

Relates to M.S. in Civil Engineering or M.S. in Engineering Science

CE 506 Remote Sensing of the Environment
CE 602 Geographic Information System
EvSc 613 Environmental Problem Solving
EnE 660 Introduction to Solid and Hazardous Waste Problems

Health Care Information Systems

Depending on courses, relates to M.S. in Management or to M.S. in Biomedical Informatics, offered jointly with UMDNJ. This certificate is offered in cooperation with UMDNJ.

BINF 5005 Health Care Information Systems *or*
MIS 645 Operations, Management, Planning and Control
BINF 5100 Introduction to Biomedical Informatics *or*
BME 669 Quantitative Physiology for Engineers
MIS 620 Computing Concepts for Managers
MIS 690 Executive Information Systems

Object-Oriented Design

Relates to M.S. in Computer Science or M.S. in Information Systems

CIS 601 Object-Oriented Programming in C++
CIS 673 Software Design and Production Methodology
CIS 683 Object-Oriented Software Development
CIS 684 Business Process Innovation

Practice of Technical Communications

Relates to M.S. in Professional and Technical Communication

Eng 601 Advanced Professional and Technical Communication
Eng 605 Document Design and Desktop Publishing
Two courses from:
Eng 613 Multimedia Presentations
Eng 620 Proposal Writing
Eng 622 Collaborative and Interpersonal Communication
Eng 624 Professional and Technical Editing

Programming Environment Tools

Relates to M.S. in Computer Science or M.S. in Information Systems

CIS 601 Object-Oriented Programming in C++
CIS 603 Advanced Programming Environments and Tools
Two courses from:
CIS 604 Client/Server Computing
CIS 631 Data Management System Design
CIS 658 Multimedia Systems
CIS 785 Selected Topics in Computer and Information Science I: Introduction to Client/Server Architecture

Project Management

Relates to M.S. in Engineering Management

EM 631 Legal Aspects in Environmental Engineering
EM 636 Project Management
EM 637 Project Control
EM 691 Cost Estimating for Capital Projects

Telecommunications Networking

Relates to M.S. in Electrical Engineering, M.S. in Computer Science or M.S. in Telecommunications (pending approval)

CIS 652 Computer Networks-Architecture, Protocols and Standards
{CIS 656 Internetworking and Higher Layer Protocols *or*
{EE 783 Computer Communications Networks
EE 673 Random Signal Analysis I
EE 683 Computer Network Design and Analysis

Courses of Instruction

NJIT Courses

The courses listed here have been approved in accordance with the policies of NJIT. The list is intended as a guide for planning programs of study. Department or university needs may necessitate changes in this list, and courses may be cancelled because of insufficient registration. A list of scheduled courses will be issued by the Registrar before each semester begins. Information found in the Degree Programs section of this catalog also serves as a guide for program planning in consultation with departmental or program advisors.

ALPHABETICAL CODE

Acct	Accounting
Arch	Architecture
BINF	Biomedical Informatics
BME	Biomedical Engineering
CE	Civil Engineering
ChE	Chemical Engineering
Chem	Chemistry
CIS	Computer and Information Science
CoE	Computer Engineering
EE	Electrical Engineering
Econ	Economics
EM	Engineering Management
EnE	Environmental Engineering
Eng	English
EPS	Environmental Policy Studies (formerly SSPS, STS)
EvSc	Environmental Science
Fin	Financial Management
Hist	History
HRM	Human Resource Management
IE	Industrial Engineering
Math	Mathematics
ME	Mechanical Engineering
Mech	Mechanics
Mgmt	Management
MIP	Infrastructure Planning
MIS	Information Systems Management
MnE	Manufacturing Systems Engineering
Mrkt	Marketing Management
MtSE	Materials Science and Engineering (formerly MtSc)
OM	Operations Management and Systems
Phys	Physics
Tran	Transportation

NUMERICAL CODE

Numbers from 500 to 599 (500G to 599G for Architecture) indicate courses normally offered for students who require additional background for admission to 600- or 700-level courses.

Numbers from 600 to 699 indicate intermediate-level graduate courses normally associated with master's-level study.

Numbers from 700 to 799 indicate advanced-level graduate courses normally associated with doctoral-level study.

Rutgers-Newark Courses

The number preceding each course title is divided into three parts. The first two digits are the administrative code (standing for a faculty or a school), the next three digits are the subject code, and the final three digits are the course code.

Administrative Codes: The following administrative code is used in this catalog.

26 Graduate School-Newark

Subject Codes: The following subject codes are used in this catalog.

120 Biology
460 Geology
510 History
755 Physics
790 Political Science
834 Public Administration

Course Codes: Two course codes separated by a comma indicate that each term course may be taken independently of the other, e.g., 26:70:537,538.

Courses numbered in the 500s and 600s are for graduate students in advanced-degree programs. Courses numbered in the 700s are ordinarily intended for students preparing individual research theses for advanced degrees.

UMDNJ Courses

The UMDNJ courses listed in this catalog are at the 5000 and 6000 level and correspond to NJIT's 600-level courses, those normally associated with master's-level study.

Accounting

Offered by the School of Industrial Management

Acct 515
Accounting for Managerial Control
3 credits
Case study approach to accounting issues that have an impact on management decision making: nature of managerial accounting, cost behavior, cost-volume-profit analysis, full costing and its use, standard costs, variances, differential cost analysis, and responsibility accounting.

Acct 610
Internal Auditing Concepts and Procedures 3 credits
The entire internal audit function including planning, surveying, audit performance, work paper documentation, reporting, standards, controls, sampling, and fraud detection.

Acct 615
Concepts of Strategic Cost Analysis
3 credits
Builds on traditional concepts of managerial accounting (break-even analysis, alternate choice decisions, profit planning, and transfer pricing) and develops the skills that an executive needs in strategic cost analysis. Explores strategic decisions of value chains and activity-based management. Emphasis on using managerial accounting data in executive planning and control.

Acct 630
Concepts and Applications of Control
3 credits
Examines the need for and implementation of internal controls to protect corporate assets. Emphasizes the role of the controller in the organization.

Acct 650
Operational Auditing 3 credits
Stresses the functions of the auditor in assessing the effectiveness and efficiency of operations. Includes such areas as environmental auditing, auditing the human resource management function, auditing OSHA, psychological impact on internal auditors, auditing in a just-in-time environment, ethics, and auditing for fraud. Financial

areas are discussed only to the extent of their operational impact.

Acct 670
Seminar in Accounting Theory 3 credits
Focuses on contemporary areas relating to accounting theory. Taught from the viewpoint of the corporate controller.

*Acct 675
Cost-Value Analysis 3 credits
Discusses the use of accounting and other data to analyze decisions faced by the manager. Considers the areas of budgeting, cost control, identification of benefits as well as the various evaluation tools.

Acct 680
Seminar in Auditing 3 credits
Discusses contemporary auditing topics as they impact on management control and decisions.

Acct 690
Seminar in Taxation 3 credits
Focuses on contemporary issues in taxation as they impact on the corporate decision making process.

Architecture

Offered by the School of Architecture

Arch 500G
Computer Programming and Graphics Problems 2 credits
Introductory computer science with applications in computer graphics for architecture. Emphasizes programming methodology using a high-level language as the vehicle to illustrate concepts. Basic concepts of computer systems, software engineering, algorithm design, programming languages, and data abstraction, with applications.

Arch 501G
Architectural Design I 5 credits
Prerequisite: graduate level standing. Core Studio. Fundamentals of architectural design. Sequence of projects explore two- and three-dimensional design. Choice of form and aesthetics is related to spatial resolution of function and context. Design as a representational medium is emphasized.

Arch 502G
Architectural Design II 5 credits
Prerequisites: Arch 501G, Arch 521G, Arch 528G, Arch 555G. Core Studio. Extends the knowledge of design, basic concepts and ideas introduced in Arch 501G. Emphasis is on developing technical drawing, and model-making skills. Also covered are two- and three-dimensional composition. Links to the history and theory sequence are made.

*pending

Arch 503G
Architectural Design III 5 credits
Prerequisites: Arch 502G, Arch 511G, Arch 522G, Arch 529G. Core Studio. Intermediate design studio. Introduction to structure; properties of materials both physical and in the abstract; and building on knowledge gained from construction and structures courses, spatial demands and design possibilities of different structural systems. Design of structure type, model and context, and comparisons of building typology for rational structure. Drawing and its role in design thinking.

Arch 504G
Architectural Design IV 5 credits
Prerequisites: Arch 503G, Arch 512G, Arch 523G. Core Studio. Second semester intermediate design studio. Design of buildings and integration of systems, physical and conceptual. Design methodology generates new information on buildings as coherent assemblies of systems. Also covers analysis and synthesis of form and introduction to applications of computer-assisted design (CAD). Preparation of design portfolio will complete core studio sequence.

Arch 505G, Arch 506G, Arch 507G
Advanced Design Options I, II, III 6 credits each
Prerequisites: completion of all core courses or their equivalent. Required vertical studio electives; must be taken sequentially. Covers a range of advanced design issues in depth: integration of organizational, social, technical, spatial, and aesthetic issues within consistently articulated applied design solutions.

Arch 511G
Structures I 3 credits
Prerequisites: graduate level standing, college level physics and calculus or equivalent, Arch 521G. Introduces structural statics through timber and steel design. Analysis and selection of building materials and structural systems related to their impact on building design.

Arch 512G
Structures II 3 credits
Prerequisites: Arch 511G, Arch 522G. Builds on information presented in Arch 511G. Emphasizes details and methods of concrete design, mixing, pouring and testing. Methods and details of steel design are summarized.

Arch 513G
Structures III 3 credits
Prerequisite: Arch 512G. Review of methods and procedures for choosing structural systems. Overview of differences among wood, steel and concrete systems. Students are introduced to complex structural behavior, prestressed concrete and new structural technology.

Arch 521G
Construction I 3 credits
Prerequisite: graduate level standing. Introduction to the construction process and how it relates to architecture. Compatibility of materials and methods of construction are studied with respect to wood, heavy timber, steel and masonry construction. Emphasis is placed on materials compatibility, construction technology, and the role of architectural documents in the construction process.

Arch 522G
Construction II 3 credits
Prerequisite: Arch 521G. Continuation of 521G. Construction practices and details of steel, precast and poured-in-place concrete construction. Review of testing methods, procedures for setting standards, forces of determination, and new materials research. Emphasis is on materials and systems selection criteria.

Arch 523G
Building Performance 3 credits
Prerequisites: Arch 522G, college level physics or equivalent. Impact on building design of heat, air movement, and thermal mass in an array of climatic conditions. Also covered are dynamic thermal and passive solar analysis for energy-conscious architectural design.

Arch 524G
Environmental Control Systems 3 credits
Prerequisite: Arch 523G. Analysis of different configurations of building equipment systems related to building design and life cycle costs. Relationships among mechanical, electrical, plumbing and transport systems are examined. The role of the architect and other professionals in equipment design and selection are studied, with an emphasis on criteria for system selection.

Arch 528G
History of Architecture I 3 credits
Prerequisite: graduate level standing. Introduction to the history of architecture. Emphasis on classical architecture from antiquity to the modern period. Evolution of the various themes and theories that underlie western architecture is presented chronologically.

Arch 529G
History of Architecture II 3 credits
Prerequisite: Arch 528G. Continuation of Arch 528G. Introduces concepts of modernism and brings the history of western architecture to the contemporary period.

Arch 555G
Architectural Graphics 3 credits
Prerequisite: graduate level standing. Documentary, descriptive and denotative media are introduced. Also covers methods of representation, delineation and reproduction. Skills are developed in technical drawing, perspective construction, projections, and format design.

*Arch 569G
Building and Development 3 credits
Familiarization with the larger process of building production, of which architecture is one important part. Focus on the role of the architect in the areas of current building de-

velopment process, how the process is evolving, and how redefinition or change might improve the process. Includes lectures about the total building process and interviews with the various actors involved in designing, approving and making buildings. Students assist in interviewing and complete a term project.

Arch 579G
Professional Architectural Practice
3 credits
Prerequisite: completion of M.Arch. core sequence. Review of the formal, informal, legal, and ethical obligations of the professional architect. Traditional relationships among the architect, clients, engineers and other participants in the design and building industry are studied. Principles of office management and problems of liability are introduced. Also fulfills core requirement of dual degree option for M.Arch./Master of Science in Management.

Arch 619
Architectural Photography 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G. Photography for architectural presentations and portfolios. Lectures include orientation on light and space, slide presentations, and the use of text to reinforce photographic material. Demonstrations include basic darkroom techniques, and methods to encourage experimentation in photography.

Arch 630
Methodology of Architectural History, Theory and Criticism 3 credits
Prerequisites: Arch 528G, Arch 529G. This seminar is structured around notable readings on architectural history, theory and criticism to provide students with a sound basis for critical analysis and assessment. It is recommended for students who select history and theory as their area of concentration.

Arch 631A
History of Renaissance Architecture
3 credits
Prerequisites: Arch 528G, Arch 529G. Development of architecture and urban design in Italy and elsewhere in Europe during the Renaissance: re-emergence of classical Greek and Roman architectural tradition; social, political and economic developments; and formal intentions and transformations in mannerist, baroque and rococo styles.

Arch 631C
History of Modern Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Major tendencies in architectural theory and practice from the mid-19th to the mid-20th centuries. Formal and stylistic transformation considered in relation to theory, social, cultural, and technical developments.

Arch 631D
History of American Architecture 3 credits
Prerequisites: Arch 528G, Arch 529G. Aesthetic, social, cultural and technical developments in American architecture and planning, from colonial times to the mid-20th century.

Arch 631E
History of Non-Western Architecture
3 credits
Prerequisites: Arch 528G, Arch 529G. Examination of major architectural traditions and styles of China, Japan, Southeast Asia, India and the Middle East.

Arch 631F
Thresholds of Architectural Theory
3 credits
Prerequisites: Arch 528G, Arch 529G. Seminar on Western architectural theory dating from Vitruvius to the present time. Examines critical texts and studies related building and projects.

Arch 631H
History and Theory of Infrastructure
3 credits
The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Teams use case studies to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. *Same as MIP 631.*

Arch 632
Problems and Methods in Architectural Preservation 3 credits
Prerequisites: Arch 528G, Arch 529G and Arch 631D. Theory and practice of preservation planning. Compares American and European preservation concepts, problems and techniques. Also covers theories on continuity and change in urban environments, and preservation-planning for community development and neighborhood conservation.

Arch 634
History of Architectural Technology
3 credits
Prerequisites: Arch 528G, Arch 529G. Survey of the development of building methods and materials. Impact of structural and environmental technology on architectural form and the design process. The role of technology in contemporary architectural theory and practice including the modern movement is emphasized. Recommended for students who select building science as their area of concentration.

Arch 640
Acoustics 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G, Arch 523G, Arch 524G. Architectural acoustics: how we hear, physics of sound and materials, aesthetics of design and the processes of construction. Audible sounds, their interaction, perception of echo and directional hearing are applied to interior and exterior building transmission, room acoustics, and setting acceptable acoustical environments.

Arch 641
Experiments in Structural Form 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G, Arch 511G, Arch 512G, Arch 513G, Arch 523G, Arch 524G. Architectural form through model design, construction and testing of minimum structures, including elements of soap film study, orthogonal and diagonal grids, design of tension grids through deflection loading, photoelastic models and calculation. Also compares geometric systems, patterning and proportion, symmetry, asymmetry, relative size, nesting, linearity and spiral orders, rectilinear patterns, and randomness in architectural structure and form.

Arch 643
Lighting 3 credits
Prerequisites: Arch 501G, Arch 502G, Arch 503G, Arch 523G, Arch 524G. Through modeling and calculation, influence of the luminous environment on architectural form and detail. Perceptions of visual comfort and daylight are examined. Topics include daylighting footprints, model design and testing, and computer-assisted, light-level analysis. Relationship between daylight and artificial light in architecture, variations of light with time, analysis of seasonal and weather differences, role of task in lighting strategies, and means of control for light quantity and quality.

Arch 644
Systems Approach to Design and Construction 3 credits
Prerequisite: completion of core sequence. Lectures, case studies and student projects on understanding human aspirations and needs through design. Topics include land, finance, management, technology and labor.

Arch 645
Case Studies in Architectural Technology 3 credits
Prerequisite: completion of core sequence. Case-study method used for in-depth investigation of the relationship among various technological systems in a building and technologically-related problems in architecture and construction.

Arch 646
Designing and Optimizing the Building Enclosure 3 credits
Prerequisite: completion of core sequence. Considers the "building envelope," the boundary dividing the inside of a structure from the outside environment. Students study and design optimal enclosures considering energy exchange, the relationship between energy and lighting, and life cycle costs.

Arch 647
Special Topics in Computer Applications 3 credits
Prerequisite: completion of core sequence. Evaluation and use of computer graphics hardware and software for architectural applications. Focus is on computers as tools, operating systems and methods of data manipulation. Two- and three-dimensional modeling software are discussed, and assignments using such software are given to provide understanding of the modeling of built environments.

Arch 649
Life Safety Issues in Contemporary Buildings 3 credits
Prerequisite: completion of the core sequence. A variety of life safety and comfort situations are studied in different building types. Topics include building evacuation, compartmentalizing, fire fighting and suppression, evaluation and testing of new building materials and systems, systems control and management. Special attention is placed on multi-use, high-density buildings.

Arch 650
Economy of Building 3 credits
Prerequisite: completion of the core sequence, SS 201 or equivalent. Economic consequences of design decisions. Topics include: relationship among economy, efficiency and quality; life-cycle cost of design; improving the economy of building processes and products through innovation; and environmental concerns. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

Arch 651
Real Estate Analysis for Architects 3 credits
Prerequisite: completion of the core sequence. Introduction to the economic, financial and political aspects of real estate and their effect on architectural decision-making. Topics include: needs assessment, real estate appraisal, financial instruments, regulations and real estate, design as value-adding, and the effect of tax policies on real estate development. This course is required for the dual degree M.Arch./Master of Science in Management program. It can also be used as an elective in the M.Arch. program.

Arch 652
Architectural Project Management 3 credits
Prerequisites: completion of the core sequence and Arch 579G. Management of architectural projects: project costs, timing, personnel, documentation, professional ethics and resource management. This course is required for the dual degree M.Arch./Master of Science in Management program. It may be used as an elective in the M.Arch. program.

Arch 661
Directed Studies of Architecture 3 credits
Prerequisites: completion of core and two elective courses; and approval from the graduate advisor. Independent, in-depth research on an analytical, theoretical or technical area of architecture. Student prepares formal research proposal with permission of faculty advisor and approval of graduate advisor. Required as pre-thesis research. See also course description for MARC 701.

Arch 662
Special Topics in Architecture 3 credits
Topics vary each semester. Refer to the School of Architecture bulletin during university registration periods for a list of current topics and possible prerequisites.

Arch 672
Architecture and Social Change 3 credits
Prerequisite: graduate level standing. Analysis of architectural form with respect to political, economic and technological change. The built environment is studied in relation to society and culture. The role of design professions in initiating or supporting change is also considered.

Arch 673
Introduction to Infrastructure Planning 3 credits
An introduction to infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. *Same as MIP 673.*

Arch 674
Infrastructure and Architecture 3 credits
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. *Same as MIP 674.*

Arch 675
Elements of Infrastructure Planning 3 credits
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. *Same as MIP 675.*

Arch 676
The Architecture of Utopia 3 credits
Prerequisite: graduate level standing. Seminar looks at several ideas of utopia from literature and philosophy and how they embody transformations in the structure of space, and their architectural implications.

Arch 678
Graduate Problems in Modern Housing 3 credits
Prerequisite: graduate level standing. Students learn to analyze political, technical and economic aspects of contemporary housing policy and practice. Attempts to provide well-designed, affordable housing responsive to the needs of large numbers of people are examined. Examples of housing from the mid-19th century to the present day are outlined.

Arch 680
Graduate Co-op Work Experience I 3 additive credits
Prerequisites: Arch 501G, Arch 502G, Arch 511G, Arch 521G, Arch 522G, Arch 528G, Arch 529G, Arch 555G, permission from graduate advisor and Office of Cooperative Education and Internships. Students gain work experience and reinforcement of their academic programs. An architecture faculty Co-op advisor monitors and evaluates student work and project. Co-op work experiences may be acceptable equivalents for apprenticeships mandated by the New Jersey State Board of Architects and for eligibility to take the architecture licensing examination. This course is required for participation in the Housing Fellows Program. Course does not fulfill degree requirements.

Arch 681/682
Graduate Co-op Work Experience II and III 3 additive credits
Prerequisites: Arch 503G, Arch 504G, Arch 512G, Arch 513G, Arch 523G, Arch 524G, permission of graduate advisor and Office of Cooperative Education and Internships. Used for extended summer-fall (681) or spring-summer (682) work experience. Does not fulfill degree requirements.

Arch 686
Research Methods for Environmental Design 3 credits
Introduction to methods of inquiry useful to professionals planning and designing buildings, communities and cities. Skills developed in problem definition and phenomena: measurement, modeling, testing and evaluation. Open to undergraduates with permission of instructor.

MARC 701
Thesis 7 credits
Prerequisites: Arch 506G, Arch 661, and approval from graduate advisor. Alternative to Arch 507G. Under the supervision of a faculty advisor, independent study of issues in the student's area of concentration developed during Arch 661.

MSAS 701
Master of Science in Architectural Studies Thesis 10 credits
Prerequisites: completion of required courses, electives, Arch 661 and approval from MSAS advisor. Under supervision of a thesis advisor, independent, in-depth examination of a subject in the student's area of concentration developed during Arch 661.

Biology

Offered by the Department of Biology at Rutgers-Newark

26:120:536
Multivariate Biostatistics 3 credits
Prerequisite: biostatistics. Covers a variety of statistical techniques useful in ecological and behavioral research. Includes sampling methods, multiple regression, discriminant analysis, weighted regression, and multidimensional chi-square. Emphasis on a conceptual understanding of the uses, assumptions, and limitations of each technique.

26:120:551
Biology of Pollution 3 credits
Prerequisite: ecology or permission of instructor. Survey of major environmental pollutants, their occurrence in the environment, their effect on biota at the cellular and physiological levels, as well as their effects at the population, community, and ecosystem levels. Emphasis on aquatic pollution.

26:120:604
Microbiology: Principles and Applications 3 credits
Restricted to NJIT students only. An introduction to microorganisms for graduate students in Environmental Sciences or Chemical Engineering. Emphasis is on the growth, physiology, and environmental effects of bacteria.

26:120:616
Topics in Biology
Credits by arrangement with the department.

Biomedical Engineering

Offered by the Biomedical Engineering Committee

BME 669
Quantitative Physiology for Engineers 3 credits
An introduction to mammalian physiology for students enrolled in the biomedical engineering program, or for students interested in the fundamental principles of mammalian physiology, particularly the heart, lungs and kidneys.

BME 672
Biomaterials 3 credits
Prerequisite: Mech 232 (see undergraduate catalog for description) or the equivalent. Materials and processes used to develop devices that are implanted in the human body; clinical aspects of biomechanical engineering; federal government requirements for design and testing of human implant devices; biocompatibility, metal implant devices, material design parameters, plastic and ceramic devices, sterilization techniques, and their effect on biocompatibility.

BME 701
Thesis in Biomedical Engineering 3 or 6 credits
Prerequisite: written permission from thesis advisor. Projects include design, construction, experimental or theoretical investigation of the engineering applications to the diagnosis and/or treatment of disease. Research may be in cooperation with industry or medical institutions. Completed work should be of sufficient quality to be acceptable for publication. Oral presentations are required.

BME 791
Seminar in Biomedical Engineering 1 credit
This course is required for the M.S. in Biomedical Engineering. Students will present discussions on their thesis research. Guest speakers will also be invited to present developments in biomedical engineering.

Biomedical Informatics

Offered by the School of Health Related Professions, UMDNJ, and Department of Computer and Information Science. Courses are taken at UMDNJ.

BINF 600/BINF 5100
Introduction to Biomedical Informatics 3 credits
Introduction to mainframe and microcomputer interactive computing environments: overview of computer applications for medical records; clinical, laboratory, pharmacy, education, and medical database management; patient care and hospital information systems using software for spreadsheets database management, telecommunication, and literature retrieval. Also covers a decentralized hospital computer program, and computer stored ambulatory record systems. Programming environment in relation to existing databases will be discussed. Students complete small hands-on projects.

BINF 601/BINF 5005
Health Care Information Systems 3 credits
General systems theory applied to health care systems and information technology. Computer-based information system operation and management functions in the context of various professional settings, and the impact of information technology on health care management are reviewed and discussed. Demonstrations of current health information systems emphasizing design, system components, data structures and database management are conducted. Costs and benefits of current applications, justification, specification and evaluation of computer systems, and the capacity for future modification and development of existing systems in various health care settings.

BINF 602/BINF 5020
Biomedical Modeling and Decision-Making Systems 3 credits
Introduction to use of differential equations and relevant mathematical concepts to describe health care and physiological systems. Methods and resources of computer simulation and modeling for analyzing and solving medical and health-care problems related to both organization and treatment, including decisions for effective information transfer, productivity and resource utilization, as well as physiological systems such as drug dosage, pulmonary transport, cardiac output, kidney function, and others.

BINF 603/BINF 5030
Visualization in Biomedical Sciences 3 credits
Fundamentals of biomedical signal and image processing including image digitization, display, and processing algorithms with emphasis on computer systems, processing methodologies, and display of images. Visualization procedures, tools and technologies for 3-D representation of images, animation and image manipulation are provided.

BINF 612/BINF 5125
Clinical Problem Solving and Decision Making 3 credits
An overview of computer methodology for clinical decision making. Application of decision trees for clinical and health care problems, estimation and revision of probabilities. Artificial intelligence, expert systems and decision-making techniques and their implementation as decision support systems in clinical and HIS settings. Examination of quantitative and symbolic approaches to medical decision making including application of statistical methods (discriminant and Bayesian statistics), decision analysis and utility theory.

BINF 613/BINF 5130
Health Care Decision Support Systems 3 credits
Overview of methods of decision support in health sciences, including artificial intelligence, Bayesian methods, classical multivariate analysis, dynamic screening (Markov) models, and theoretical and empirical limitations of these decision methods. Discussion of literature on human perception and judgment as well as practice on database management software and expert system tools to design decision support prototype systems for clinical, health care finance and patient management systems.

BINF 614/BINF 5135
Clinical Systems Interface Design 3 credits
Prerequisites: BINF 5100, BINF 5005 and BINF 4000 or equivalent. Practice of princi-

ples of interface design, data exchange, program-to-program communication, and knowledge-based systems using Windows-based GUI design packages. Exposure to application development tools with expert system shell capabilities and system integration tools with good communication interfacing between various hardware platforms from PCs to minicomputers and mainframes. Exploration of a wide array of user interface system design and development techniques. Term project using the GUI package required.

BINF 615/BINF 5150
Seminar: Biomedical Teaching Systems Design 1 credit
Based on knowledge gained from courses in biomedical informatics, students engage in serious discussion and analysis of the various aspects of computer-based instructional systems. Examples of technologies covered include: microcomputer courseware, CD/ROM, CD-I, DVI, instructional television, interactive microcomputer and videodisc systems, multimedia intelligent tutoring and expert systems, and instructional games and simulations.

BINF 621/BINF 5210
Research Methods in Health Sciences 3 credits
Use of computer as a tool for scientific inquiry including techniques for searching computer database of research literature, and formulating problems and hypotheses for statistical analysis of educational, health services, laboratory and clinical data. Use of computers in management and analysis of health science data. Laboratory instruction in use and application of software packages for micro- and mainframe computers. Issues in the design, organization and operation of randomized controlled clinical trials and intervention studies, and analysis of qualitative and quantitative data.

BINF 631/BINF 5311
Intelligent Instructional Systems
3 credits
Current developments and trends in instructional technology applied to knowledge and learning in health science: processes of perception, learning, motivation, problem-solving and decision making in relation to the design of intelligent tutoring and educational expert systems. The students will work with knowledge engineering, expert system and authoring tools to develop intelligent tutorials and expert system models on selected/assigned topics.

BINF 632/BINF 5312
Interactive Learning Systems for the Health Sciences 3 credits
Introduction to use of interactive videodisc and CD-ROM technology for health sciences instructional software. Students try existing interactive software and videodiscs on biomedical subjects, and then design, edit and evaluate an interactive videodisc learning module of their own.

BINF 700/BINF 6000
Directed Research/Project
6 credits

Chemical Engineering

Offered by the Department of Chemical Engineering, Chemistry, and Environmental Science

ChE 551
Principles of Mass Transfer 3 credits
Prerequisites: undergraduate thermodynamics and integral calculus. An introductory course in basic concepts of mass transfer. Special emphasis is placed on mass transfer concepts applicable to stage and continuous operations. Topics covered include evaporation, gas absorption, and distillation. Cannot be used for degree credit.

ChE 583
Petroleum Refining 3 credits
Prerequisites: undergraduate courses in chemical engineering, kinetics, and mass transfer. A study of the major petrochemical feedstocks. A consideraton of the economic and technical problems in refinery operation with changing sources of raw materials and demands for products.

ChE 590
BS/MS Co-op Work Experience I
3 additive credits
Prerequisite: restricted to BS/MS co-op students in chemical engineering. Permission from department and Office of Cooperative Education and Internships. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations during the summer months. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

ChE 591
BS/MS Co-op Work Experience II
3 additive credits
Prerequisite: restricted to BS/MS co-op students. Permission from department and Office of Cooperative Education and Internships. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations during summer months. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

ChE 592
Co-op Work Experience III
3 additive credits
Prerequisite: graduate standing. Permission from department and Office of Cooperative Education and Internships. Cooperative education internship provides on-the-job reinforcement of academic program by placement in major-related work situations for a minimum of three months. Work assignments developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

ChE 599
Methods for Teaching Assistants and Graduate Assistants 3 credits
Prerequisite: graduate standing. Required for all chemical engineering teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Cannot be used for degree credit.

ChE 602
Selected Topics in Chemical Engineering I 3 credits
Prerequisite: advisor's approval or permission of the instructor. Topics of current interest in chemical engineering.

ChE 611
Thermodynamics 3 credits
Prerequisites: undergraduate courses in physical chemistry and thermodynamics, or equivalent. Principles of thermodynamics developed quantitatively to include thermodynamic functions and their application to chemical engineering processes.

ChE 612
Kinetics of Reactions and Reactor Design 3 credits
Prerequisite: undergraduate course in chemical engineering kinetics, or equivalent. Elements of optimum design introduced for reactor types, series and parallel reactor systems, multiple reactions, and temperature effects. Introduction to non-ideal reactor design. Study of various models for catalytic and non-catalytic solid-fluid reactions.

ChE 623
Heat Transfer 3 credits
Prerequisite: undergraduate course in heat transfer. Heat transmission applied to practical problems in design. Unsteady state conduction and batch heating and cooling problems; and empirical correlations and their use in the design and optimization of equipment.

ChE 624
Transport Phenomena I 3 credits
Prerequisites: undergraduate courses in fluid mechanics, heat transfer, and mass transfer. A unified treatment of molecular and turbulent momentum, energy, and mass transport. Emphasis is on the mathematical description of physical mechanisms in momentum and energy transport.

ChE 625
Microlevel Modeling in Particle Technology 3 credits
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. *Same as ME 624.*

ChE 626
Mathematical Methods in Chemical Engineering 3 credits
Prerequisite: undergraduate course in differential equations. The purpose of the course is to emphasize the importance of mathematics to chemical engineering practice. Applications of non-linear regression, series solution of ordinary differential equations, Sturm-Liouville problems in partial differential equations, and numerical methods. It is suggested that students take this course before taking ChE 624.

ChE 627
Introduction to Biomedical Engineering 3 credits
Prerequisites: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored.

ChE 628
Biochemical Engineering 3 credits
Prerequisite: undergraduate degree in chemical engineering. The application of chemical engineering to biological processes, biochemical reaction systems, and their technological use. Special attention given to problems in momentum, energy, and mass transport, as well as chemical reaction kinetics in biological systems.

ChE 629
Biological Engineering Analysis 3 credits
Prerequisite: undergraduate degree in chemical engineering. Emphasis is on chemical engineering reactor design employing microbial populations. The dynamics of microbial interactions are described mathematically, as are cell attachment and reactor stability.

ChE 631
Equilibrium Stage Processes 3 credits
Prerequisite: undergraduate chemical engineering courses in stage separations and mass transfer. Correlations and computation methods used in applying the equilibrium stage concept to the design of separation processes; absorption, extraction, and distillation treated as variations of one basic process; equipment design, and tower controls are described.

ChE 634
Chemical Process Dynamics and Control 3 credits
Prerequisite: undergraduate chemical engineering course in process dynamics and control. Mathematical principles of process dynamics and control; derivation and solution of differential equations describing the behavior of typical chemical engineering processing units; and mathematical analysis and design of control systems. Digital and sampled data control systems also discussed.

ChE 641
Chemical Equipment and Plant Design 3 credits
Prerequisite: undergraduate degree in chemical engineering. The design of a chemical manufacturing plant or a major process segment; selection of the major pieces of equipment; auxiliaries and associated utility requirements and instrumentation; and general specifications for the offsite facilities, plant site preparation, and overall plant layout.

ChE 645
Fundamentals of Rheology 3 credits
Prerequisite: ChE 626 or permission of the instructor. Rheology of polymer melts and polymer solutions. Various types of time-dependent and time-independent non-Newtonian fluids are classified. Experimental techniques used to characterize these materials are discussed.

ChE 646
Polymerization Reactor Design and Analysis 3 credits
Prerequisite: ChE 612 or equivalent. Mathematical analysis of polymerization systems occurring in batch, continuous stirred tank, and tubular reactors, including stability, control, and optimization.

ChE 656
Catalysis 3 credits
Prerequisite: ChE 612. Introduction of mass transfer and physical characterization of catalysts: the effectiveness factor; absorption; surface reaction; catalytic reactor design.

ChE 657
Multiphase Reaction Engineering 3 credits
Prerequisite: ChE 612. Complex reactor systems of commercial importance are studied, including gas-liquid, fluid-solid, and fluid-fluid-solid systems, as well as reactive distillation, and bioreactors.

ChE 661
Coal Conversion Engineering 3 credits
Prerequisite: undergraduate degree in chemical engineering. Physical and chemical properties of coal. Coal storage, handling, transportation, cleaning and preparation. Chemistry, thermodynamics, and kinetics of coal pyrolysis, hydropyrolysis, gasification, and liquefaction. Engineering analysis of the various coal conversion processes. Characteristics of fluidized and entrained bed reactors.

ChE 662
Chemical Processing of Electronic Materials 3 credits
Prerequisite: undergraduate degree in chemical engineering. Processes necessary for manufacturing electronic materials into semiconductor devices and systems including single crystal growth, chemical vapor deposition, ion implantation, dry etching, and other considerations.

ChE 663
Operations Analysis of Chemical Manufacturing Processes 3 credits
Prerequisite: undergraduate degree in chemical engineering. Introduction of mathematical tools and analytic approaches needed to manage resources, operations and product quality in a chemical engineering plant. Topics include cost analysis, decision analysis, production planning, energy conservation, process optimization, reliability analysis, and statistical quality control.

ChE 671
Chemical Process Safety 3 credits
Prerequisite: admission to the master's program in occupational safety and health engineering. Chemical and physical principles in chemical process safety and fire and explosion hazard evaluation. Emphasis is on materials, their reactions, and effect on surroundings. Course intended for students in the master's program in occupational safety and health engineering, and may not be taken for credit by ChE graduate students.

ChE 675
Statistical Thermodynamics 3 credits
Prerequisite: ChE 611 or permission of instructor. Application of equilibrium statistical mechanics to chemical engineering problems. Basic postulates and relationships of statistical thermodynamics, including the ideal gas, ideal crystal, and virial equation; statistical theories of fluid mixtures and other advanced topics.

ChE 685
Industrial Waste Control I 3 credits
Prerequisite: EvSc 610 or equivalent, or undergraduate degree in chemical engineering. Physical/chemical treatment of industrial wastewaters: ionic equilibria; surface characterization; thermodynamic applications; transport phenomena; and sludge treatment.

ChE 686
Industrial Waste Control II 3 credits
Prerequisite: EvSc 610 or equivalent, or undergraduate degree in chemical engineering. Biological treatment of industrial wastewaters: biological mechanisms; kinetics; vapor-liquid equilibria; and settling phenomena.

ChE 687
Industrial Gas Cleaning 3 credits
Prerequisites: undergraduate degree in chemical engineering, or permission of the instructor. Review of available tools for cleaning atmospheric effluents from manufacturing facilities and power plants; use of a systems approach to minimize gas cleaning costs; alternatives involving combinations of process modification and effluent clean-up; methods for estimating key design parameters for cyclones, baghouses, electrostatic precipitators and scrubbers. Applications of design parameters through the solution of extensive problem-sets.

ChE 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree in chemical engineering. Approval of thesis advisor is necessary for registration. Original research, design, or process development under the guidance of a departmental advisor. The final product must be a written thesis. The thesis must be approved by three faculty members: one from the department, the primary advisor, and one other faculty member. Once registration for thesis has begun, a student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved.

ChE 702
Selected Topics in Chemical Engineering II 3 credits
Prerequisite: advisor's approval or permission of instructor. Topics of current interest in chemical engineering.

ChE 705
Independent Study 3 credits
Prerequisites: permission from the graduate advisor (not thesis advisor) in chemical engineering, as well as courses prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

ChE 711
Phase Equilibrium 3 credits, 2nd sem.
Prerequisite: ChE 611. Low-pressure and high-pressure vapor-liquid equilibrium and liquid-liquid equilibrium. Among the topics covered are experimental methods, consistency tests of the data, expressions for the dependence of the activity coefficient on composition and temperature, and prediction of multicomponent vapor-liquid and liquid-liquid equilibrium from binary data. Prediction methods of vapor and liquid phase nonidealities, based on equations of state and solution theories, are discussed.

ChE 712
Optimization of Chemical Reactor Systems 3 credits
Prerequisites: ChE 612 and ChE 626. Optimization theory and practice. Various types of reactors are considered from the viewpoint of optimal design.

ChE 725
Transport Phenomena II 3 credits
Prerequisite: ChE 624. Transport in laminar and turbulent flow: in solids, between phases, and macroscopic transport in flow systems.

ChE 726
Applied Fluid Mechanics 3 credits
Prerequisite: ChE 624. Brief review of the equations of change and tensor analysis; generalized Newtonian fluid and its flow, material function for non-Newtonian fluids through porous media.

ChE 731
Advanced Techniques in Equilibrium Separations 3 credits
Prerequisite: ChE 631. Methods for rigorous stage process calculations as well as date correlations and consideration of design degrees of freedom. Emphasis is placed on computer techniques and on use of the computer by students to solve problems. Special topics such as sidestream stripping, azeotropic and extractive distillation, and separation accompanied by chemical reaction are also covered.

ChE 735
Optimization in Process Design and Control 3 credits
Prerequisites: ChE 626 and ChE 634 or equivalent. Optimization techniques developed mathematically, and applied to problems in chemical design and control. Methods of calculus of variations and dynamic programming are compared; the discrete maximum principle applied to problems in design of multi-stage chemical processes (e.g., cross-current extraction and a stirred tank reactor sequence).

ChE 740
Biological Treatment of Hazardous Chemical Wastes 3 credits
Prerequisite: ChE 686 or the permission of the instructor. A doctoral level seminar on the limitations of biological treatment for hazardous wastes that looks at the fundamental processes taking place.

ChE 741
Modern Methods in Process and Plant Design 3 credits
Prerequisites: previous course in process or plant design; ChE 611, ChE 612 and ChE 626. Newer concepts of process and plant design synthesis, analysis, and optimum design methods. Among the specific topics covered are process development, evaluation, and licensing; structure of process design problems; economic design criteria; computer-aided design methods; effects of uncertainty on designs; and the various non-process factors that affect a plant design such as contractor's responsibilities, project management, and cost control.

ChE 757
Catalytic Reactor Design 3 credits
Prerequisites: ChE 624 and ChE 656. Mass, energy, momentum transfer and chemical reactions involved in fixed bed, fluidized bed, trickle bed, and slurry reactors.

ChE 790
Doctoral Dissertation and Research
Credits as designated.
Required of all students for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of thesis advisor is necessary for registration. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached and then for 3 credits each semester thereafter until completion.

ChE 791
Graduate Seminar 1 credit
Required of all chemical engineering or chemistry graduate students receiving departmental or research-based awards. The student must register for one credit per semester until completion of the degree. Outside speakers and department members will present their research for general discussion. Does not count as degree credit.

Chemistry

Offered by the Department of Chemical Engineering, Chemistry, and Environmental Science

Chem 502
Advanced Organic Chemistry I 3 credits
Prerequisite: undergraduate organic chemistry. Structure of organic molecules. Topics include atomic and molecular structure, stereochemistry, reactive intermediates (cations, anions, radicals, and carbenes), orbital symmetry, and spectroscopy.

Chem 540
Introduction to Polymers 3 credits
Prerequisite: undergraduate physical chemistry or thermodynamics. Synthesis of typical polymers of commercial importance; determination of the size and shape of polymer molecules and the morphology of crystalline polymers; mechanical properties of polymers in the crystalline, glassy and elastomeric states as related to structure; properties of available polymers for specific applications.

Chem 552
Laser Chemistry and Technology 3 credits
Prerequisites: one year of chemistry, one year of physics, and calculus. An introduction to the underlying chemical and physical prin-

ciples of lasers, their operation and uses and the related optoelectronic technology. Analysis of classes of laser; pumping mechanisms; detection of light; absorption and emission of radiation and current industrial and state-of-the-art uses.

Chem 599
Methods for Teaching Assistants and Graduate Assistants 3 credits
Prerequisite: graduate standing. Required for all chemistry teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety.

Chem 601
Special Topics in Chemistry I 3 credits
Prerequisite: advisor's approval or permission of instructor. Topics of current interest in chemistry.

Chem 602
Advanced Organic Chemistry II 3 credits
Prerequisite: undergraduate organic chemistry. The study of organic syntheses including principles underlying chemical reactions; chemical thermodynamics, structural theory, rates of reaction, mechanisms and stereochemistry; IR, UV, and NMR spectroscopy; organic synthesis; formation of aliphatic carbon-carbon bonds; pericyclic reactions; carbon-nitrogen bonds; electrophilic and nucleophilic aromatic substitution, molecular rearrangements; photochemical and free-radical reactions; oxidation and reduction; and organometallic reagents containing phosphorous, boron, sulfur, and silicon.

Chem 603
Advanced Organic Chemistry Laboratory 3 credits
Prerequisite: undergraduate organic chemistry. More advanced syntheses than those normally carried out in the undergraduate laboratory are emphasized including current analytical techniques and methods of separation. Both small and large scale preparations are assigned.

Chem 606
Physical Organic Chemistry 3 credits
Prerequisite: Chem 502 or equivalent. Emphasis is placed on the physical aspects of the subject. Determination of reaction mechanisms, equilibria, and kinetics using simple molecular orbital theory and absolute reaction rate theory.

Chem 610
Advanced Inorganic Chemistry 3 credits
Prerequisite: undergraduate physical chemistry or permission of the instructor. Theories of observed chemical and physical properties of the elements and their compounds; prediction of reactivity and properties of proposed new compounds.

Chem 611
Solid-State Inorganic Chemistry 3 credits
Prerequisite: undergraduate physical chemistry or physics. Structure, physical and chemical properties of solid-state materials, and their formation.

Chem 624
Modern Organic Chemistry 3 credits
Prerequisite: one year of general chemistry. Relationship of organic chemistry to the contemporary world. Review of basic bonding theory and organic reactions. Current research on mechanistic and structural problems; natural sources of organic compounds; uses in preparation of pharmaceuticals, and other commercially important chemicals.

Chem 625
Geochemistry 3 credits, 1st or 2nd sem.
Prerequisite: Chem 624. Primarily a study of the chemistry of the lithosphere. Topics discussed include the origin of the earth and its chemical evolution, organic geobiochemistry, and extraterrestrial geochemistry.

Chem 626
Chemistry of Contemporary Materials 3 credits
Prerequisite: one year of general chemistry. An introduction to the structure and chemical, electrical, and mechanical properties of metallic, ceramic, and polymeric materials and their use in science and engineering.

Chem 627
Modern Physical Chemistry 3 credits
Prerequisite: one year of general chemistry. The course considers relevant topics in thermodynamics, equilibrium, kinetics, states of matter, and surface chemistry including their applications in technology and the environment.

Chem 628
Radiation and the Environment 3 credits
Prerequisite: one year of general chemistry. The course covers both the harmful and useful aspects of radiation. A brief introduction to nuclear physics and radioactivity is followed by consideration of the problems of radiation units, interaction of radiation with biological systems, dosimetry, and radiation regulations. The numerous applications of radiation and radioactive materials, with emphasis upon nuclear power, its effluents, and its effect on the environment will also be discussed.

Chem 640
Polymer Chemistry 3 credits
Prerequisites: organic and physical chemistry. Kinetics of polymerization; properties of polymer solutions; characterization of molecular size and shape. Students who have completed Chem 540 will not be granted degree credit for Chem 640.

Chem 641
Polymer Properties 3 credits
Prerequisite: Chem 540 or Chem 640 or instructor's approval. Forces between polymer molecules and their relation to crystal structure; fundamentals of rheology and viscoelastic properties of polymers; polymer crosslinking, reinforcement, and aging from a chemical viewpoint.

Chem 643
Polymer Laboratory I 3 credits
Prerequisites: Chem 440, Chem 540 or Chem 640. Experimental preparations of polymers and copolymers. Preparations include standard condensation, free radical, emulsion, and ionic types. Elementary methods of polymer characterization and extrusion are included.

Chem 644
Fundamentals of Adhesion 3 credits
Prerequisite: Chem 540 or Chem 640 or equivalent. Adhesion phenomena; intermolecular and interatomic forces; surface chemistry; absorption of polymers on surfaces; mechanisms of adhesion; bulk properties of adhesives; and rheology of polymers used as adhesives.

Chem 645
Polymer Laboratory II 3 credits
Prerequisite: Chem 640 or Chem 643. Experiments illustrating contemporary methods of polymer characterization including osmometry, viscometry, laser light scattering, vapor pressure osmometry, differential thermal analysis, dilatometry, x-ray diffraction, birefrigence, polymer factionation/gel permeation chromatography, extrusion, swelling crosslinking, molding, viscoelasticity, and infrared, ultraviolet, and NMR spectroscopy.

Chem 651
Radioisotopes Theory and Application 3 credits
Prerequisite: modern physics. Theory and principles of the application of radioisotopes in nuclear physics and instrumentation; legal and safety aspects of radioisotopes; calculations to design a tracer experiment and specific applications of radioisotopes to industrial problems.

Chem 654
Corrosion 3 credits
Prerequisite: one year of general chemistry. Fundamental principles including thermodynamics and kinetics of corrosion; forms of corrosion (e.g., galvanic crevice and stress); methods of corrosion measurement; high temperature corrosion; and special case histories.

Chem 655
Electrochemistry: Principles and Applications 3 credits
Prerequisites: one year of general chemistry and a course in physical chemistry or equivalent. Principles governing electrochemical methods such as conductance, emf, polarography, cyclic voltammetry,

chronopotentiometry, coulometry, and their application to electric energy storage and conversion, corrosion, electroplating, pollution monitoring, electrochemical sensors, and electrochemical synthesis.

Chem 658
Advanced Physical Chemistry 3 credits
Prerequisite: one year of undergraduate physical chemistry. Principles and applications of quantum chemistry; the wave equation, its properties and mathematics; the Schrodinger equation and wave functions; the harmonic oscillator; variational and perturbational methods; atomic theory, structure, and properties; simple molecules, LCAO and valence bond theories; semi-empirical methods; time dependence, and introduction to electronic and vibration-rotation spectroscopy.

Chem 659
Atomic and Molecular Structure 3 credits
Prerequisite: Chem 658 or equivalent. Application of quantum chemistry and molecular structure; techniques for calculation of physical properties of molecules; and use of state-of-the-art computer graphics. Student computational experience not necessary.

Chem 661
Instrumental Analysis 3 credits
Prerequisite: one year of physical chemistry. The various instruments used for chemical and environmental analysis; basic theory; use of instruments and interpretation of data; UV-VIS, IR spectroscopy: NMR, AA; HPLC, GC; and mass spectroscopy.

Chem 662
Air Pollution Analysis 3 credits
Prerequisites: undergraduate general chemistry and undergraduate general physics. Chemical and physical principles of gaseous species and trace level measurement techniques for airborne vapors and particulates. Emphasis on analyzing real air samples at the parts-per-billion level, meteorological dispersion and life times of pollutants are covered. Laboratory work in air pollution sampling methods for vapor and particulate species. Determination of primary air pollutants using wet chemical and instrumental techniques.

Chem 664
Advanced Analytical Chemistry 3 credits
Prerequisite: undergraduate physical chemistry. The principles of chemical analysis as they apply to chromatography, electrochemistry, and spectroscopy. Sampling considerations, separations, and sample preparation steps. This course is a useful adjunct to Chem 661, where these analytical techniques are considered in a more practical way.

Chem 670
Environmental Toxicology for Engineers and Scientists 3 credits
Prerequisite: Chem 673 or equivalent. Toxicology at the molecular level, including methods of evaluation and quantification, as well as mechanisms of absorption, distribution, metabolism, and excretion of toxicants. Discussions of systemic toxicology (e.g., liver, kidneys, nervous system) and survey of toxic agents. Particular emphasis placed on environmental toxicology including air, water and soil pollutants, food additives, and contaminants.

Chem 671
Industrial Toxicology Workshop 3 credits
Prerequisite: Chem 670 or equivalent. A case study approach that applies basic theory and methods of toxicology to real-life problems related to hazardous materials transport, toxic commercial products and by-products, chemical industrial fires, unsafe landfills and illegal dumping.

Chem 673
Biochemistry 3 credits
Prerequisites: undergraduate organic and physical chemistry, or suitable background in these subjects. Fundamentals of biochemistry related to physical organic chemistry for students who have an interest in biomedical engineering, chemistry, chemical engineering, or environmental science.

Chem 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Approval to register for the master's project must be obtained from the project advisor. Students must continue to register for at least 3 credits each semester until the project is completed and a written report is accepted.

Chem 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree in applied chemistry. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by three faculty members: one from the department, the primary advisor, and one other faculty member. Once registration for thesis has begun, a student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved.

Chem 702
Special Topics in Chemistry II 3 credits
Prerequisite: advisor's approval or permission of instructor. Topics of current interest in chemistry.

Chem 705
Independent Study 3 credits
Prerequisites: permission from the graduate advisor (not thesis advisor) in chemistry, as well as courses prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

Chem 734
Thermochemical Kinetics—Detailed Mechanistic Modeling 3 credits
Prerequisite: graduate level course in either kinetics or reactor design, or permission of instructor. Quantitative estimation of thermochemical data and chemical reactions in the vapor phase, and to some extent in the liquid phase; theories of transition state, RRKM, and Quantum RRK; and detailed chemical modeling concepts for reactor design. Applied computer project is required.

Chem 735
Combustion 3 credits
Prerequisite: thermodynamics and kinetics or equivalent, or permission of instructor. Thermodynamic properties of stable molecules and free radical species in combustion and oxidation of aliphatic hydrocarbons; reactions occurring in high temperature combustion systems; and related kinetic principles.

Civil Engineering

Offered by the Department of Civil and Environmental Engineering

CE 501
Introduction to Soil Behavior 3 credits
Prerequisites: CE 320, Mech 235 and Mech 236 (see undergraduate catalog for descriptions). Open only to the students in bridge program. Permission from CEE department graduate advisor is required. Covers the necessary concepts in strength of materials, geology and soil mechanics required for the bridge program in M.S. in Environmental Engineering and Geoenvironmental Engineering option.

CE 506
Remote Sensing of Environment 3 credits
Prerequisite: Phys 234 (see undergraduate catalog for description). Covers the principles of remote sensing, general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for civil engineering practices. Data collection from airborne and satellite platforms will be emphasized. Photographic and nonphotographic sensing methodologies will be covered as well as manual and computer assisted data analysis techniques for site investigations and examination of ground conditions.

CE 530
Applied Finite Element Method 3 credits
Prerequisites: CE 332 and CIS 101 (see undergraduate catalog for descriptions). Introduction to applications of finite element

method to problems of structural analysis and design. Review of matrix algebra and the stiffness method of structural analysis. Applications include trusses, frames, plates, shells, and problems of plane stress/strain. Emphasis on use of finite element method in design offices.

CE 531
Design of Masonry and Timber Structures 3 credits
Prerequisite: CE 332 (see undergraduate catalog for description). Study of basic properties of clay and concrete masonry units and wood. The masonry segment includes discussion of unreinforced bearing walls subjected to concentric as well as eccentric loads. Lateral-force resistance of unreinforced and reinforced masonry systems are introduced and new developments to strengthen and retrofit unreinforced masonry walls are discussed. The timber design portion includes design and behavior of wood fasteners, beams, columns, and beam-columns as well as introduction to plywood and glued laminated members.

CE 545
Rock Mechanics I 3 credits
Prerequisite: approved undergraduate course in soil mechanics within last five years or permission of instructor. Rock mechanics including geological aspects, mechanical properties, testing, and in-situ measurements of rock properties, and a brief introduction to design of structures on rock.

CE 552
Geometric Design of Transportation Facilities 3 credits
Prerequisite: CE 350 or equivalent (see undergraduate catalog for description). Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. *Same as Tran 552.*

CE 553
Design and Construction of Asphalt Pavements 3 credits
Prerequisite: senior standing in civil engineering. Importance of designing proper asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. *Same as Tran 553.*

CE 590
BS/MS Co-op Work Experience I
3 additive credits, 1st or 2nd sem. or summer.
Prerequisites: standing and acceptance in the combined BS/MS program and permission from the civil engineering department and Office of Cooperative Education and Internships. Cooperative education/internship providing on-the-job reinforcement of academic programs in civil engineering. Work assignments and projects are developed by the co-op office in consultation with the civil engineering department; and evaluated by CE faculty co-op advisors.

CE 591
BS/MS Co-op Work Experience II
3 additive credits, 1st or 2nd sem. or summer
Prerequisites: CE 590 and permission from the civil engineering department and Office of Cooperative Education and Internships. Continuation of CE 590.

CE 592
Co-op Work Experience III
3 additive credits, 1st or 2nd sem. or summer
Prerequisites: CE 591, graduate standing and permission from the civil engineering department and Office of Cooperative Education and Internships. Continuation of CE 591.

CE 601
Advanced Remote Sensing 3 credits
Prerequisite: a first course in remote sensing. Principles of computer processing of satellite and aircraft remote sensing data as well as image enhancement, image transformation and image classification techniques using advanced image analysis system—ERDAS in the interactive mode. Multiple applications on land use/land cover, water quality assessment and terrain evaluation will be emphasized. During final weeks of the semester students will apply the acquired techniques to specific projects.

CE 602
Geographic Information System 3 credits
Prerequisite: course or working knowledge of CADD or permission of instructor. Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces this emerging technology and its applications. *Same as Tran 602.*

CE 603
Introduction to Urban Transportation Planning 3 credits, spring
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. *Same as Tran 603.*

CE 604
Environmental Modeling in Remote Sensing 3 credits
Prerequisites: CE 602 and CE 605. Advanced course consisting of three main components: review of current research and literature dealing with environmental RS/GIS, applied and computer modeling of land and oceans; case studies in RS/GIS applications, emphasizing "real world" environmental problems, presented by outside experts; and presentation of student projects.

CE 605
Research Methods in Remote Sensing
3 credits
Prerequisites: CE 601 and Math 661. Major components of RS data acquisition systems, overview of image processing techniques with emphasis on neural network and traditional pattern recognition, principal component transformations, and data reduction. Emphasizes geometric and mapping aspects of RS/GIS techniques for linking RS images with spatial data, sources of error, and accuracy assessment techniques. Hands-on experience with existing hardware/software (ERDAS & GENESIS).

CE 610
Construction Management 3 credits
Prerequisite: B.S. degree in CE, technology, architecture, or related field. Managerial aspects of contracting. Study of an individual firm in relation to the entire construction industry. Topics include contractor organization and management, legal aspects of construction, and financial planning.

CE 611
Project Planning and Control 3 credits
Prerequisite: CE 610. Management tools as related to construction projects are analyzed and applied to individual projects. Emphasis is on network scheduling techniques, time-cost analysis, resource allocation and leveling, cost estimating, bidding strategy, and risk analysis.

CE 614
Underground Construction 3 credits
Prerequisite: undergraduate course in soil mechanics. Various aspects of underground construction, including rock and soft ground tunneling; open cut construction; underpinning; control of water; drilling and blasting rock; instrumentation; and estimating underground construction costs. Case studies and a field trip to an underground construction site will be included.

CE 615
Infrastructure and Facilities Remediation
3 credits
Prerequisites: graduate standing in civil engineering and basic knowledge of structures, and material science. Examines the methodology of inspection, field testing, evaluation and remediation of existing in-

frastructure and facilities, which include pipelines, tunnels, bridges, roadways, dams, and buildings. Typical materials distress and failure scenarios will be covered with remediation options through the use of case studies.

CE 616
Construction Cost Estimating 3 credits
Prerequisite: CE 610. Full range of construction cost-estimating methods including final bid estimates for domestic building and heavy/highway projects; computerized takeoff and estimating techniques; international construction; financial and cost reporting; databases; indices; risk; competition; performance; and profit factors.

CE 618
Applied Hydrogeology 3 credits
Prerequisites: undergraduate courses in earth science/geology, fluid mechanics, and calculus or permission of instructor. Examines ground water and contaminant movement through the subsurface environment. A basic understanding of the aquifer geology is emphasized. Hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater are introduced.

CE 620
Open Channel Flow 3 credits
Prerequisite: undergraduate fluid mechanics. The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

CE 621
Hydrology 3 credits
Prerequisite: undergraduate fluid mechanics. The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.

CE 622
Coastal Engineering 3 credits
Prerequisites: fluid mechanics and calculus. An introductory course covering basic wave theory, sediment transport and ocean circulation. The application of these principles to various coastal engineering problems will be discussed, including beach erosion, pollution transport in coastal waters, and the design of shore protection structures.

CE 623
Groundwater Hydrology 3 credits
Prerequisites: undergraduate fluid mechanics and computer programming, or consent of instructor. Basic principles of groundwater hydraulics; Darcian analysis of various aquifer systems; unsaturated flow into porous mediums; transport of contaminants in soil media; and mathematical models for fluid and contaminant transport.

CE 625
Public Transportation Operations and Technology 3 credits, spring
Prerequisite: graduate standing in a cross-listed department or instructor approval. Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems. *Same as IE 625 or Tran 625.*

CE 630
Matrix Analysis of Structures 3 credits
Prerequisites: undergraduate courses in theory of structural analysis and computer programming. A review of matrix operation and energy method, and development of flexibility and stiffness methods used in linear-elastic structural analysis. Behavior of continuous beams, plane trusses and frames, and space trusses and frames will be studied.

CE 631
Advanced Reinforced Concrete Design 3 credits
Prerequisite: an undergraduate course in theory and design of reinforced concrete. A review of basic concepts of elastic and ultimate strength theories and a study of the present design codes. Topics include: design of concrete building frames, two-way slabs, flat slabs, deep beams, and other structural elements using the above two theories.

CE 632
Prestressed Concrete Design 3 credits
Prerequisite: undergraduate course in theory and design of reinforced concrete. Analysis and design of pre-tensioned and post-tensioned prestressed concrete elements for both determinate and indeterminate structures will be studied. Examples of prestressed elements used in buildings and bridges will be discussed, as well as the source and magnitude of prestress losses.

CE 634
Structural Dynamics 3 credits
Prerequisite: undergraduate course in structural analysis. Dynamic analysis of beams, frames, and other types of structures. Practical methods developed are applied to problems such as the analysis of the effects of earthquakes on buildings and moving loads on bridges.

CE 635
Fracture Mechanics of Engineering Materials 3 credits
Prerequisites: graduate standing in civil and/or mechanical engineering and basic knowledge of structures and mechanics of materials. Basic principles of fracture mechanics to increase understanding of cracking and fracture behavior of materials and structures. Emphasis on practical applications of fracture mechanics.

CE 636
Stability of Structures 3 credits
Prerequisite: undergraduate course in theory of structural analysis. Topics include: structural design concept; stability criteria; elastic and inelastic bucklings; column buckling; lateral buckling of beams; stability of frames; stability of plates and shell; local buckling and post-buckling.

CE 637
Short Span Bridge Design 3 credits
Prerequisite: undergraduate courses in steel design and concrete design, and some knowledge of prestressed concrete fundamentals. Design and performance of highway and railroad bridges, particularly steel and prestressed concrete structures since they are most common in the northeast; and computer applications including bridge geometry, abutment design and composite beam design.

CE 638
Nondestructive Testing Methods in Civil Engineering 3 credits
Familiarizes the civil engineering student with nondestructive testing (NDT) techniques currently employed for evaluation and condition monitoring of civil structures and construction materials. Major emphasis in the application of NDT methodologies to steel, concrete, and timber as the construction material. Covers theories, principles, and testing methodologies associated with individual technologies from specific material point of view. Discusses advantages and limitations pertaining to the application of individual NDT technologies to construction materials.

CE 641
Engineering Properties of Soils 3 credits
Prerequisite: approved undergraduate course in soil mechanics within last five years. An in-depth study of physical and mechanical properties of soils. Topics include clay mineralogy, shear behavior and compressibility of fine and coarse grained soil; and in-situ measuring techniques such as vane shear, core penetration and pressure meter. Laboratory work includes consolidation test and triaxial test, with emphasis on analysis, interpretation and application of data to design problems.

CE 642
Foundation Engineering 3 credits
Prerequisites: approved undergraduate courses in soil mechanics and foundation engineering. The salient aspects of shallow

foundation design such as bearing capacity and settlement analyses. Topics are relevant to the deep foundation, selection of the type and the determination of load bearing capacity from soil properties, load tests, and driving characteristics utilizing wave equation analyses. Earth pressure theory and retaining wall design.

CE 643
Advanced Foundation Engineering
3 credits
Prerequisite: CE 642. Lateral and earth pressure computations for the design of retaining walls, bulkheads, cellular cofferdams, and sheetpiles. Also considers the design of internal bracing systems and anchors, soil nailing and reinforced earth. Slope stability of embankments and dams.

CE 644
Geology in Engineering 3 credits
Prerequisites: undergraduate courses in soil mechanics and geology. Review of the fundamentals of physical geology and discussion of the theory and the applications of geophysical methods with emphasis on geoenvironmental engineering. Presentation of concepts pertaining to natural hazards such as earthquakes, mass wasting, and well logging and coastal geology. Students are expected to prepare and present at least one relevant case history. Not recommended for geology majors.

CE 645
Rock Mechanics II 3 credits
Prerequisite: CE 545 or equivalent, or permission of instructor. Applications of design problems in underground structures, subways, stability of rock slopes, blasting, and seismic effects. A design project is a course requirement.

CE 646
Geosynthetics and Soil Improvement
3 credits
Prerequisite: CE 341 (see undergraduate catalog for description). Includes engineering properties of geosynthetics and their application in civil engineering, such as filtration, seepage, and erosion control; subgrade and slope stabilization. Soil improvement topics include preloading, electrokinetic stabilization, soil modification, admixtures and grouting.

CE 647
Geotechnical Aspects of Solid Waste
3 credits
Prerequisites: CE 341, CE 341A or equivalents (see undergraduate catalog for description). Geotechnical aspects of solid waste such as municipal landfill, dredged materials, coal and incinerator ashes, identification and classification of waste materials, geological criteria for siting, laboratory and field testing, design for impoundment and isolation of waste, methods of stability analyses of landfill sites, techniques for stabilizing waste sites, leachate and gas collection and venting systems. Primary emphasis is on municipal wastes.

CE 648
Flow Through Soils 3 credits
Prerequisite: CE 641. Explains the fundamentals of fluid flow through saturated and unsaturated soils and the use of computer programs for the solution of boundary value fluid flow problems in soils. The first two-thirds of the course are devoted to flow through saturated soils. The topics are mathematical description of flow through soils, solutions for steady state and transient state fluid flow and geotechnical applications. The last one-third is devoted to flow through unsaturated soils. Topics include steady state of transient state fluid flow and a presentation of how these concepts are applied to geoenvironmental problems.

CE 650
Urban Systems Engineering 3 credits
Prerequisites: B.S. degree in engineering or in the physical or social sciences with some computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty. *Same as Tran 650.*

CE 653
Traffic Safety 3 credits
Prerequisite: CE 660. System behavioral principles are applied to safety aspects of highway operation and design, and improvements of existing facilities. Solutions are evaluated on the basis of cost effectiveness. *Same as Tran 653.*

CE 655
Land Use Planning 3 credits
Spatial relations of human behavior patterns to land use; methods of employment and population studies are evaluated; location and spatial requirements are related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. *Same as Tran 655.*

CE 659
Flexible and Rigid Pavements 3 credits
Prerequisite: CE 341 or equivalent (see undergraduate catalog for description). Types of rigid (Portland cement) and flexible (bituminous) pavements. Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. *Same as Tran 659.*

CE 660
Traffic Studies and Capacity 3 credits, fall
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using the highway capacity software (HCS) and SIDRA. *Same as Tran 615.*

CE 661
Analysis and Design of Shell Structures
3 credits
Prerequisite: undergraduate course in structural analysis. Methods of analysis and design of shell structures for building. Topics include: domes, hyperbolic paraboloids, folded plates, and cylindrical shells. Materials considered include reinforced and prestressed concrete.

CE 700
Civil Engineering Projects 3 credits, 1st or 2nd sem.
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of civil engineering problems not covered by regular graduate course work is required. A student with an exceptional project in CE 700 may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for CE 701 Master's Thesis.

CE 701
Master's Thesis 6 credits, 1st or 2nd sem.
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester until completion and submittal of an approved document. Credit will be limited, however, to the 6 credits indicated for the thesis.

CE 702
Special Topics in Civil and Environmental Engineering 3 credits, 1st or 2nd sem.
Prerequisite: advisor's approval. Topics of special current interest in civil and environmental engineering. This course may be taken as an independent study with a faculty advisor, with permission of the department chair.

CE 705
Mass Transportation Systems 3 credits
Prerequisites: CE 625 and Tran 610. An investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. *Same as Tran 705.*

CE 710
Systems in Building Construction
3 credits
Requirements and benefits of various building construction systems. Preliminary examination of the interrelation between design and construction. Topics include lift slab and tilt-up construction, slipforming, precasting, joist systems, modular construction, and mechanical and electrical systems.

CE 711
Methods Improvement in Construction
3 credits
Prerequisite: CE 610. Improved methods in construction; various techniques of work sampling and productivity measurement; and current innovations in the construction industry for increasing efficiency.

CE 720
Water Resource Systems 3 credits
Prerequisites: CE 620, CE 621. A system methodology is applied to the analysis of water resource development and operation. Topics include operational hydrology, water quality criteria, streamflow requirements, resource allocation, and economics. Mathematical models are developed and employed in the evaluation of a case study.

CE 725
Independent Study I 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 726
Independent Study II 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 727
Independent Study III 3 credits
Prerequisites: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

CE 730
Plastic Analysis and Design 3 credits
Prerequisite: CE 630. Theory of plasticity applied to structural design. Study of methods of predicting strength and deformation of single and multi-story steel frames in the plastic range. Comparison of plastic and prestressed concrete.

CE 733
Design of Metal Structures 3 credits
Prerequisites: CE 630 and CE 636. Methods of design of metal structural systems. Topics include combined action of unsymmetrical sections, torsion of open and closed sections, buckling of columns and plates with various end conditions, and design of curved and boxed girders.

CE 734
Design of Tall Buildings and Space Structures 3 credits
Prerequisites: CE 630 and CE 636. Design of tall buildings and space structures emphasizing framing systems, and recent developments and current research related to the design of such structures.

CE 736
Finite Element Methods in Structural and Continuum Mechanics 3 credits
Prerequisites: a working knowledge of computer programming, and Mech 630 and CE 630. Finite element approaches for analysis of plane stress problems, plates in flexure, shells, and three-dimensional solids; and choice of interpolation functions, convergence, and the capabilities of the methods.

CE 737
Earthquake Engineering 3 credits
Prerequisite: CE 634. Practical design solutions for resisting the damaging effects of earthquake ground motions and other severe dynamic excitations. Factors which control dynamic response in elastic and inelastic ranges, and the nature of severe dynamic excitations. Theories of structural analysis and dynamics, and modern design methodologies on the behavior of structures.

CE 738
Advanced Matrix Analysis of Structures
3 credits
Prerequisite: CE 630. Advanced topics from structural analysis, including nonlinear analysis of trusses, frames and membrane finite elements, collapse by buckling, analysis and design of fabric structures.

CE 739
Structural Optimization 3 credits
Prerequisite: CE 630. Application of methods of mathematical programming to problems of optimal structural design. Optimal criteria methods, discrete and continuous systems, and code design will be covered.

CE 741
Theoretical Soil Mechanics 3 credits
Prerequisite: CE 641. An advanced graduate course for Ph.D. students and interested M.S. students in Civil Engineering. Explains the fundamentals of constitutive models for soils and their use in the solution of boundary value problems. Covers the theory of elasticity and theory of plasticity as tools in developing constitutive models for soils. Introduces critical state concept for soils. The triaxial experimental behavior of soils is discussed to introduce the concept of soil flow and strength. Critical state concept and elastoplastic material concepts are incorporated in the constitutive models, models predictions will be compared with experimental results for sands and for clays. Constitutive models will incorporated into finite element codes to analyze boundary value problems such as stability of slopes and performance of footings.

CE 742
Geotechnology of Earthquake Engineering
3 credits
Prerequisite: CE 641. Explains the fundamentals of propagation of the earthquakes through soils to supporting structures and the use of computer programs in the solution of boundary value problems in soils. The first half is devoted to synthesis of earthquakes, mathematical formulation of the problem, measurement of applicable soil parameters, use of computer programs to solve 1-D wave propagation problems in soils with structures. The second half is devoted to soil liquefaction, soil-structure interaction, and design of machine foundations.

CE 743
Contaminant Transport in Soils 3 credits
Prerequisites: CE 618, CE 623 and CE 648. An advanced graduate course for Ph.D. students and interested M.S. students in civil, environmental, and chemical engineering. Explains the fundamental mechanisms involved in the organic chemical flow and transport in soils. Includes new concepts and recent findings associated with leaking underground storage tanks. First half deals with flow of nonaqueous phase liquids (NAPL) through a soil-water-air system. The second half discusses the sorption and dissolution of organics in the soil-water-air system, and transport of organics in the dissolved phase.

CE 751
Transportation Design 3 credits
Prerequisite: CE 603. Design problems, airports, terminals, and highway intersections and interchanges are undertaken. *Same as Tran 751.*

CE 752
Traffic Control 3 credits
Prerequisite: CE 660. Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM. *Same as Tran 752.*

CE 753
Airport Design and Planning 3 credits
Prerequisites: Tran 610 and CE 660. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA

operating requirements. Financial, safety and security issues. *Same as IE 753 and Tran 753.*

CE 754
Port Design and Planning 3 credits
Prerequisites: Tran 610 and CE 660. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as IE 754 and Tran 754.*

CE 765
Multi-Modal Freight Transportation Systems Analysis 3 credits, spring
Prerequisites: Tran 610 or equivalent and CE 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as EM 765 and Tran 765.*

CE 790
Doctoral Dissertation and Research
Credits as designated
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for at least 6 credits of dissertation per semester. Registration for additional credits may be permitted beyond the 6, with the approval of the advisor, to a maximum of 15 credits per semester. If the dissertation is not completed after 36 credits, registration for an additional 3 credits per semester is required thereafter. Registration for 3 credits is permitted during the summer session, hours to be arranged.

CE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for CE 790 unless requirement is waived, in writing, by the Dean of Graduate Students.

CE 793
Professional Project Credits as designated
Required of all students working toward the Degree of Engineer. A minimum of 12 credits is required. The student must register for at least 6 credits of professional project per semester, until completion of 12 credits. If the student is still actively preparing the project after completion of 12 credits, continued registration of 3 credits per semester will be required. Registration for 3 credits is permitted during the summer session, hours to be arranged.

Computer Engineering

Offered by the Department of Electrical and Computer Engineering

CoE 651
Computer Systems Architecture 3 credits
Prerequisites: EE 684 and CoE 353 (see undergraduate catalog for description) or CIS 650. Discussion of advanced topics in modern computer systems architecture such as pipelined and superscalar processors, parallel computers (vector, SIMD, MIMD), multi-threaded and dataflow architectures, cache and memory hierarchy, and system interconnect architectures. Also, relevant system software design issues such as shared memory and message-passing communication models, cache coherence and synchronization mechanisms, latency-hiding techniques, virtual memory management, program partitioning, and scheduling. Examples are drawn from real systems. *Same as EE 690.*

CoE 685
Network Interface Design 3 credits
Prerequisite: EE 683 or equivalent. Provides a working knowledge of data communications networking devices, the building blocks upon which networks are constructed. Emphasizes devices and their function in data communication networks. Covers the use of devices in the design, implementation, modification, and optimization of data communications networks.

CoE 700
Master's Project 3 credits
Prerequisite: written approval of project advisor. An extensive project involving design, construction, and analysis, or theoretical investigation. Cooperative projects with industry may be acceptable. Work is carried out under supervision of a member of the program faculty. A maximum of 3 credits may be applied to the degree.

CoE 701
Master's Thesis 6 credits
Prerequisite: written approval of thesis advisor. Projects involving design, construction, experimental or theoretical investigation. Cooperative projects with industry or governmental agencies may be acceptable. Work is carried on under the supervision of a designated member of the program faculty. Completed work in the form of a written thesis should merit publication in a technical journal. The completed thesis must be defended by the student in an open forum and must be approved by a committee of at least three people. A student must register for a minimum of 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

CoE 791
Graduate Seminar 1/2 credit
Required each semester for all master's students who receive departmental or research-based awards. To receive a passing grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

Computer and Information Science

Offered by the Department of Computer and Information Science

CIS 500
Introduction to Systems Analysis
3 credits
Prerequisites: statistics and differential equations. Covers a wide variety of systems oriented approaches to solving complex problems. Illustrative examples are chosen from a wide variety of applications. Mathematical tools are only introduced to the extent necessary to understand the technique and its application to the problem. Topic areas include probabilistic and decision theory models, simulation, morphological analysis, cluster analysis, structural modeling, Delphi and dynamic system models. The role for the computer in applying these techniques to complex problems will be discussed. The student will be exposed to some of the fundamental controversies concerning the appropriateness or validity of systems approaches to human problem solving.

CIS 505
Programming, Data Structures, and Algorithms 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL or C. Computer science students cannot use this course for graduate degree credit. Intensive introduction to computer science principles: a procedure-oriented language such as C++; program design techniques; introductory data structures (linked lists, stacks, sets, trees, graphs); and algorithms (sorting, searching, etc.) and their analysis. Programming assignments are included.

CIS 506
Foundations of Computer Science
3 credits
Prerequisite: knowledge of C/PASCAL. Corequisite: CIS 505. Cannot be used for graduate credit towards the M.S. in Computer Science. Introduction to the concepts of iteration, asymptotic performance analysis of algorithms, recursion, recurrence relations, graphs, automata and logic, and also surveys the main data models used in computer science including trees, lists, sets, and relations. Programming assignments are given.

CIS 510
Assembly Language Programming and Principles 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL, C, or C++. Computer Science students cannot use this course for graduate degree credit. An intensive course in assembly language programming including basic machine organization, the structure of instruction sets, program linkage, macros and macro libraries. Extensive programming assignments are included.

CIS 515
Advanced Computer Programming for Engineers 3 credits
Prerequisite: knowledge of at least one procedure-oriented language such as PASCAL, C, or FORTRAN. Students specializing in computer science may not take this course for credit. This course is designed for engineering students who require an extensive knowledge of programming for their project or thesis work. Topics include review of basic programming techniques, treatment of algorithm design, error analysis and debugging. As time permits, problem-oriented languages are examined.

CIS 540
Fundamentals of Logic and Automata
3 credits
Prerequisite: Math 226 or equivalent (see undergraduate catalog for description). Theory of logic and automata and their influence on the design of computer systems, languages, and algorithms. Covers the application of Boolean algebra to design of finite state machines; formal systems, symbolic logic, computability, halting problem, Church's thesis, and the main ideas of the theory of computation.

CIS 590
BS/MS Co-op Work Experience I
3 additive credits
Prerequisite: standing and acceptance into the combined BS/MS program in computer science. Students must have the approval of the co-op advisor for the CIS department. The entire BS/MS Co-op Work Experience sequence of courses must be completed with a single employer or the student cannot continue in the BS/MS internship. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 591
BS/MS Co-op Work Experience II
3 additive credits
Prerequisite: standing and acceptance into the combined BS/MS program in computer science. Students must have the approval of the co-op advisor for the CIS department. The entire BS/MS Co-op Work Experience sequence of courses must be completed with a single employer or the student cannot continue in the BS/MS internship. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 592
Co-op Work Experience III
3 additive credits
Prerequisites: graduate standing, and acceptance by the CIS department and the Office of Co-op Education and Internships. Students must have the approval of the Co-op advisor for the CIS department. Provides on-the-job reinforcement and application of concepts presented in the undergraduate computer science curriculum. Work assignments are identified by the co-op office and developed and approved by the CIS department in conjunction with the student and employer. Students must submit, for CIS department approval, a proposal detailing the nature of the intended work. A report at the conclusion of each semester's work experience is required. Credits for this course may not be applied toward degree requirements for either the bachelor's or master's in computer science.

CIS 599
Teaching in Computer Science 3 credits
Prerequisite: status as full-time graduate student working as teaching assistant. Must be taken each semester by CIS teaching assistants. Teaching strategies and related methodology necessary for TA's to supervise undergraduate laboratories. Course is graded either satisfactory or unsatisfactory. Cannot be counted as degree credit.

CIS 601
Object-Oriented Programming in C++
3 credits
Prerequisite: basic knowledge of C++. Covers the fundamentals of object-oriented programming. Includes object-oriented concepts such as data abstractions, encapsulation, inheritance, dynamic binding, and polymorphism, and uses C++ as the vehicle for illustrating and implementing these concepts. The object-oriented paradigm is systematically employed in the design of all concepts. Effects of this methodology on software maintenance, extensibility, and reuse. Significant programming/design projects.

CIS 603
Advanced Programming Environments and Tools 3 credits
Prerequisite: CIS 601. Introduction to Graphical User Interface (GUI) Programming in the X Windows System environment. Design and implementation of the GUI at various levels of abstraction using industry standard software tools. Trade-offs between flexibility and ease of use inherent in GUI building tools. Best suited for the advanced programmer.

CIS 604
Client/Server Computing 3 credits
Prerequisites: CIS 333 and CIS 432 or instructor approval (see undergraduate catalog for descriptions). Fundamentals of client/server architecture as applied to the development of software systems. Concepts of distributed systems such as open systems, middleware, software reengineering, and distributed computing environments. Components of distributed client/server technologies such as X Windows Systems, DCE, CORBA, NFS, and ODBC. Case studies are used to illustrate how client/server techniques can be used in a variety of applications. The importance of standards and their role in client/server architecture, such as Posix, DCE, and COS. Requires creation of distributed applications.

CIS 605
Discrete Event Dynamic Systems 3 credits
Prerequisite: Math 630 or EE 601 or MnE 603 or equivalent. Covers discrete event dynamic system theory and its applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems, robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

CIS 610
Data Structures and Algorithms 3 credits
Prerequisite: CIS 505 or CIS 335 or equivalents (see undergraduate catalog for description). Intensive study of the fundamentals of data structures and algorithms. Presents the definitions, representations, processing algorithms for data structures, general design and analysis techniques for algorithms. Covers a broad variety of data structures, algorithms and their applications including linked lists, various tree organizations, hash tables, strings, storage allocation, algorithms for searching and sorting, and a selected collection of other algorithms. Programs are assigned to give students experience in algorithms, data structure design and implementation.

CIS 611
Introduction to Computability and Complexity 3 credits
Prerequisites: mathematics bridge requirements. Introduces the theoretical fundamentals of computing, and provides an understanding of both the inherent capabilities and limitations of computation. The main models of computation are deterministic and nondeterministic Turing machines. Auxiliary models include partial and total recursive functions, first order logic, recursive and recursively enumerable sets, and symbol systems. Covers the essentials of computational theory: first order logic, Russel's Paradox, completeness and consistency, Goedel's Theorem, Church's Thesis, countable and uncountable sets, simulation and

computation, diagonalization, dove-tailing, decidable and undecidable problems, reduction, recursion theory, Rice's Theorem, Recursion Theorem, execution time measures, P and NP, polynomial-time reduction, NP-completeness and NP-hardness and formal correctness semantics of programs.

CIS 621
Numerical Analysis I 3 credits
Prerequisite: Math 511 (see undergraduate catalog for description) or an introductory course in numerical methods. An introduction to computational aspects of scientific and engineering problems. Time-dependent phenomena and corresponding quantitative models. Numerical stability and conditioning. Approximation of functions. Interpolation, integration. Solution of nonlinear equations. Ordinary differential equations of the first order. Finite and iterative algorithms for solution of systems of linear equations. Emphasis on computer implementation of algorithms and application to variety of engineering problems.

CIS 622
Numerical Analysis II 3 credits
Prerequisite: Math 511 (see undergraduate catalog for description) or an introductory course in numerical methods. This course covers the theory and design of computer solutions to mathematical equations. Included are iterative methods for solving systems of linear and nonlinear equations, the numerical eigenvalue-eigenvector problem, and methods for solving ordinary and partial differential equations. Emphasis is on the control of errors generated by the computer.

CIS 630
Operating System Design 3 credits
Prerequisites: CIS 332, CIS 432, and CIS 505 (see undergraduate catalog for description). An intensive study of computer operating system design including multiprogramming, time-sharing, real-time processing, job and task control, synchronization of concurrent processes and processors, resource scheduling, protection, and management of hierarchical storage.

CIS 631
Data Management System Design
3 credits
Prerequisites: CIS 610 and knowledge of C. Acquaintance with fundamental notions of relational database technology. Mathematical properties and usage of database programming languages. Methods of database design and conceptual modeling. Methods of physical storage for database information. Fundamental notions of concurrency control and recovery in database systems.

CIS 632
Advanced Database System Design
3 credits
Prerequisites: CIS 631 and knowledge of C. Covers the concepts and principles of object-oriented data modeling and database systems, parallel and distributed database systems, database machines, real time (database) systems, multimedia and text databases, and imprecise information retrieval systems. Emphasis is on advanced data modeling, query optimization, indexing techniques, concurrency control, crash recovery, distributed deadlock detection, real-time scheduling, vague retrieval and system performance.

CIS 633
Distributed Systems 3 credits
Prerequisites: completion of bridge requirements. Fundamental topics concerning the design and implementation of distributed computing systems are covered, including interprocess communication, remote procedure calls, authentication, protection, distributed file systems, distributed transactions, replicated data, reliable broadcast protocols, and specifications for distributed programs. All topics will be illustrated with case studies. Optional topics may include synchronization, deadlocks, virtual time, and load balancing.

CIS 634
Information Retrieval 3 credits
Prerequisites: CIS 610 and knowledge of C. Covers the concepts and principles of information retrieval systems design. Techniques essential for building text databases, document processing systems, office automation systems, and other advanced information management systems.

CIS 635
Computer Programming Languages
3 credits
Prerequisites: CIS 505 and CIS 510. The theory and design of computer language systems; the formal theory of syntax and language classification; a survey of procedure and problem-oriented computer programming languages, their syntax rules, data structures, and operations; control structures and the appropriate environments and methods of their use; a survey of translator types.

CIS 636
Compiling System Design 3 credits
Prerequisite: CIS 635. Compiler organization; interaction of language and compiler design. The front end scanning, parsing, and syntax-directed translation: theory, standard approaches, and techniques; front-end tools such as Lex and Yacc. Attribute grammars. Code generation, register allocation, and scheduling; interaction with the run-time environment. Introduction to static analysis and optimization. As time permits, topics in modern compilers: compiling for object-oriented languages such as C++ or Java, memory hierarchies, pipelining, parallelism. Includes a significant programming component.

CIS 637
Real-Time Systems 3 credits
Prerequisites: completion of bridge requirements. Theory and principles that govern real-time systems design, and mechanisms and methodologies that enable their construction and operation. All aspects of such systems will be covered, including scheduling, device and resource management, communications, machine architecture, kernel software, language design and implementation, specification and user interfaces, and performance analysis and verification techniques.

CIS 640
Recursive Function Theory 3 credits
Prerequisite: CIS 540 or equivalent. Review of basic computability theory. Topics include Church's thesis; unsolvability results; creative, productive, and simple sets; computational complexity; P = NP problem; and classification of solvable problems according to their complexity.

CIS 641
Formal Languages and Automata
3 credits
Prerequisite: Math 226 or equivalent (see undergraduate catalog for description). Fundamentals of automata and formal languages: hierarchy of abstract machines and languages; nondeterministic finite state machines; tape and pushdown automata; context-free and context-sensitive grammars.

CIS 650
Computer Architecture 3 credits
Prerequisites: CIS 251 (see undergraduate catalog for description) and CIS 510. Exploiting instruction level parallelism (ILP) is central to designing modern computers. Presents design techniques used for such computers as IBM Power architectures, DEC Alpha, MIPS R4600, Intel P6, etc. Introduction of Instruction Set Architecture (ISA), various functional units, basic principles of pipelined computers. Modern techniques to ILP including superscalar, super-pipelining, software pipelining, loop unrolling, and VLIW. Memory hierarchy, including instruction cache, data cache, second level cache, and memory interleaving. Advanced computer architectures, including vector, array processors, interconnection technology, and ATM network of workstations. Hands-on experience designing a simple pipelined computer on screen and using CAD tools such as Cadence or ViewLogic.

CIS 651
Data Communications 3 credits
Prerequisite: Math 333 (see undergraduate catalog for description). Intensive study of the analytic tools required for the analysis and design of data communication systems. Topics include: birth-death queuing systems, Erlang's distribution, bulk-arrival and bulk-service systems, design and analysis of concentrators and multiplexers, elements of Renewal Theory, M/G/1 system, analysis of Time Division Multiplexing, priority queues, analysis of random access systems, time reversibility, open and closed queuing networks, mean value analysis, flow and congestion, control mechanisms, routing algorithms, flow models, and network topological design.

CIS 652
Computer Networks-Architectures, Protocols and Standards 3 credits
Prerequisite: A high level programming language, Math 333 (see undergraduate catalog for description), or instructor approved equivalents. Intensive study of various network architecture and protocol standards; with emphasis on the Open Systems Interconnection (OSI) model. Topics include: analog and digital transmission, circuit and packet switching, the Integrated Services Digital Network (ISDN), Frame Relay, Broadband ISDN, Cell Relay, SONET, Local Area Networks (CSMA/CD, Token Bus, Token Ring, switched and isochronous Ethernets), Metropolitan Area Networks (FDDI, FDDI-II, DQDB), wireless and satellite networks, synchronization and error control, routing and congestion control, X.25 standard.

CIS 653
Microcomputers and Applications 3 credits
Prerequisite: familiarity with an assembly language. A study of the PC, based on the Intel X86 family. Includes the use of operating systems to control input and output and peripheral components, and also the base Intel X86 family assembly language. The later members of the X86 family are introduced as well as non-Intel microprocessors.

CIS 654
Telecommunication Networks Performance Analysis 3 credits
Prerequisites: CIS 651, CIS 652, or instructor approved equivalents. Modeling and analysis of telecommunication networks; with emphasis on Local Area Networks (LANs) and Metropolitan Area Networks (MANs). Case studies will be presented and discussed, and the need for modeling and analysis will be established. Various types of LANs, and MANs will be modeled and analyzed. Problem sets and case studies will be assigned to facilitate understanding of the covered material.

CIS 656
Internetworking and Higher Layer Protocols 3 credits
Prerequisite: CIS 652 or instructor approved equivalents. Intensive study of the architecture of interconnected networks and corresponding protocols that make interconnected architectures function as a single unified communication system. Topics include: Internet services (archie, gopher, veronica, wais, netfind, world wide web, mosaic, etc.), the address resolution protocol (ARP) and reverse ARP, the Internet protocol, transparent gateways and subnetting, the domain name system, routing and multicasting in the Internet, the User Datagram Protocol (UDP), the Transmission Control Protocol (TCP), the socket interface, the client-server model of interaction, TCP/IP and OSI application level protocols.

CIS 657
Principles of Interactive Computer Graphics 3 credits
Prerequisites: CIS 505 or familiarity with the organization of at least one computer system, and knowledge of a structured programming language such as C. Graduate-level introduction to computer graphics concepts, algorithms, and systems. Includes 2-D raster graphics, algorithms, 2-D and 3-D geometric transformations, 3-D viewing, curves and surfaces. Emphasis on PC-based graphics programming projects. Principles of interactive graphics systems in terms of the hardware, software and mathematics required for interactive image production.

CIS 658
Multimedia Systems 3 credits
Prerequisites: CIS 610 and CIS 657, or equivalent. Introduction to multimedia information systems; the nature of multimedia data types including text, image, audio, video and animation; multimedia data models and system architectures; design of multimedia systems including interfaces, storage models and structures, filtering, browsing and composing paradigms, query processing and information retrieval. Students will develop applications in multimedia authoring environments.

CIS 659
Image Processing and Analysis 3 credits
Prerequisite: CIS 657. Fundamentals of image processing, analysis and understanding. Topics include image representation, image data compression, image enhancement and restoration, feature extraction and shape analysis, region analysis, image sequence analysis and computer vision.

CIS 661
Systems Simulation 3 credits
Prerequisites: an undergraduate (at the level of Math 244 and Math 333; see undergraduate catalog for description) or graduate course in probability and statistics and working knowledge of at least one higher-level language (e.g., FORTRAN). An introduction to the simulation of systems, with emphasis on underlying probabilistic and statistical methodologies for discrete-event simulations; design of simulation programs in special purpose simulation languages; applications of simulation studies; algorithms for the generation of pseudorandom numbers; probabilistic process generation of queuing systems. The special purpose simulation language SIMSCRIPT is covered, with emphasis on modeling a variety of different problems and the rigorous analysis of the simulation output.

CIS 662
Model Analysis and Simulation 3 credits
Prerequisite: introductory course in simulation. Advanced topics in simulation methodology, including design of simulation experiments, variance reduction techniques, estimation procedures, validation, and analysis of simulation results. Queueing systems. Implementing a simulation with the SIMSCRIPT language. Models of continuous systems with applications to elementary socio-economic and industrial systems. Utilization of the DYNAMO II language.

CIS 665
Algorithmic Graph Theory 3 credits
Prerequisite: CIS 610. The elements of the theory of graphs and directed graphs with motivating examples from communication networks, data structures, etc; shortest paths, depth first search, matching algorithms, parallel algorithms, minimum spanning trees, basic complexity theory, planarity, and other topics. Programming assignments are included.

CIS 667
Design Techniques for Algorithms 3 credits
Prerequisite: CIS 610. An introduction to the principles of major design techniques in algorithms. Examples from a variety of topics and problems in computer science are used to demonstrate these design techniques and their appropriate application.

CIS 668
Parallel Algorithms 3 credits
Prerequisites: CIS 610 and CIS 650. This course examines a variety of parallel algorithms and architectures. Shared memory algorithms and algorithms for special architectures (tree processors, grids, systolic arrays, butterflies) are considered. The basic theory of algorithm/architecture performance will be described.

CIS 669
Computational Geometry 3 credits
Prerequisite: CIS 610 or permission of the instructor. Intensive study of the fundamentals of computational geometry data structures and algorithms. Emphasis is on the design of efficient algorithms and data structures, proofs of their correctness and complexity analysis. Fundamental topics including geometric searching, convex hull computation, nearest/farthest searching, Voronoi diagrams, Euclidean minimum spanning trees, planar triangulation, planar point location, arrangement of lines.

CIS 670
Artificial Intelligence 3 credits
Prerequisite: CIS 610. Fundamental concepts and general techniques in artificial intelligence. Main topics include goal tree search, logic and deduction, adduction, uncertainty, fuzzy logic, knowledge representations, machine learning, vision, and action planning. The LISP programming language is used extensively. Students are required to do programming assignments, complete a programming term project, and review case studies.

CIS 671
Knowledge-Based Systems 3 credits
Prerequisite: CIS 670 or equivalent. Deals with the underlying architectures of "classical" knowledge-based systems, i.e., systems based on a knowledge representation formalism that are built by knowledge acquisition from a domain expert; and advanced database systems, especially object-oriented and deductive databases.

CIS 672
Expert System Methods and Design
3 credits
Prerequisite: CIS 670. Deals with expert systems, expert system shells, programming of rule-based systems, selection of shells, verification and validation of expert systems, and knowledge acquisition techniques for extracting knowledge from domain experts.

CIS 673
Software Design and Production Methodology 3 credits
Prerequisites: CIS 630, CIS 631, and CIS 635. Modern techniques and methods employed in the development of large software systems, including a study of each of the major activities occurring during the lifetime of a software system, from conception to obsolescence and replacement. Topics include cost/performance evaluation, documentation requirements, system design and production techniques, system verification techniques, automated aids to system development, and project organization and management.

CIS 674
Natural Language Processing 3 credits
Prerequisite: CIS 670. Deals with techniques of natural language understanding. Topics are syntax and parsing (top down and bottom up), semantics, pragmatics and use of world knowledge in language understanding. Augmented Transition Networks will be used as programming tool set. Good knowledge of LISP or PROLOG.

CIS 675
Information System Evaluation 3 credits
Prerequisites: a course in statistics and CIS 677. Theoretical perspectives and methodological approaches to evaluate information systems within the context of the user and organizational environment. Topics include qualitative techniques such as protocol analysis and interviews; quantitative techniques such as sample surveys and controlled experiment; cost-benefit analysis, and analyses of data gathered by these approaches by methods such as regression, correlation, and analysis of variance. Emphasis on the application of these approaches to improve functionality, interface, and acceptance of information systems in organizations.

CIS 676
Requirements Engineering 3 credits
Prerequisites: completion of bridge requirements, CIS 673 or equivalent project experience in the field. Theory, principles, and practical application of the methodologies and tools of requirements engineering. The focus is development of large software systems and the integration of multiple systems into a comprehensive, domain dependent solution. All aspects of requirements engineering will be covered, including problem analysis, requirements specification techniques and tools, and specification of functional and non-functional requirements. Related technologies like domain analysis and pre-planned systems integration are also discussed.

CIS 677
Information System Principles 3 credits
Prerequisites: familiarity with the organization of a computer system and knowledge of at least one higher-level language. Reviews the role of information systems in organizations and how they relate to organizational objectives and organizational structure. Identifies basic concepts such as the systems point of view, the organization of a system, the nature of information and information flows, the impact of systems upon management and organizations, human information processing and related cognitive concepts. Introduces various types of applications that are part of information systems. The course focus is on management information systems.

CIS 679
Management of Computer and Information Systems 3 credits
Prerequisite: CIS 675. Management of the development, planning, and utilization of information systems within organizations. Focuses on the current literature in the management of information systems. Topics include the approval and decision process for the development of systems, use of steering committees and various approaches to user involvement. Utilizes a number of Harvard University case studies. Project utilizing professional literature required.

CIS 682
Geometric Modeling 3 credits
Prerequisite: CIS 610. The techniques required to describe the shape of an object and to simulate dynamic processes; parametric geometry of curves, surfaces, and solids; and particular formulations for facilitating calculating geometric properties. Fundamentals of solid model construction and analysis are discussed extensively. Some applications in computer graphics, CAD, and CAM are also mentioned.

CIS 683
Object-Oriented Software Development
3 credits
Prerequisites: CIS 635, experience in software design and development or explicit approval of the instructor. Advanced course in software development. Presents the object-oriented methodology for software development and examines various areas to which this methodology can be applied. Analysis, design, and implementation of object-oriented software and the effect of this methodology on code reusability, extensibility, and robustness. Examines object-oriented languages, object-oriented databases, and object-oriented user-interfaces.

CIS 684
Business Process Innovation 3 credits
Prerequisites: CIS 610, CIS 673, knowledge of C programming. Discusses a balanced approach to business software process innovation (BPI) that includes both incremental improvement and re-engineering. Introduces, as the basic framework for managing change, the notion of a process architecture activity structure, infrastructure, and coordination structure. Details a spiral BPI implementation methodology, interwoven with many case studies. Discusses a software process engineering support environment.

CIS 688
Programming for Interactive Environments
3 credits
Prerequisites: Proficiency in C, exposure to C++. A thorough study of the fundamental concepts and techniques of programming for modern interactive support environments, better known as graphical user interfaces (GUIs). A balanced blend of principle and practice, incorporating a general paradigm of interactive program development and numerous examples from, and projects in, the major GUI environments.

CIS 696
Network Management and Security
3 credits
Prerequisites: CIS 652 or EE 683, and CIS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and for protecting systems from network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms). Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). *Same as EE 638.*

CIS 697
Principles of Broadband ISDN and ATM
3 credits
Prerequisite: CIS 652 or EE 683 or equivalent. Study of the Broadband Integrated Services Digital Network (B-ISDN) architecture and services. In-depth study of the Asynchronous Transfer Mode (ATM), ATM Adaptation Layer (AAL), ATM switching architectures, SONET/SDH, ATM traffic control, broadband integrated traffic models, Operation Administration and Management (OAM) functions, TCP/IP over ATM, and ATM market. *Same as EE 639.*

CIS 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree. An approved project involving design, construction, and analysis, or theoretical investigation is required of all students in the Master of Science degree program who do not take CIS 701 Master's Thesis. A project proposal must be submitted in a prior semester by an announced date and receive faculty approval. Project work is normally initiated in a computer science course with the knowledge and approval of the instructor who will become the student's project advisor. Candidates working on projects are required to attend CIS 710 Computer Science Seminar concurrently and to present their papers orally. A student whose work in CIS 700 is of exceptional quality may be permitted to extend the master's project into a master's thesis in CIS 701.

CIS 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree. An approved project involving design, construction, and analysis or theoretical investigation may be the basis for the thesis. The work will be carried out under the supervision of a designated member of the faculty. The thesis should be of such caliber as to warrant publication in a technical or scientific journal. Students working on a thesis are required to attend a semester of CIS 710 Computer Science Seminar: They will report on their research at the seminar. Approval to register for the thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

CIS 710
Computer Science Seminar Non-credit
Presentations of active research in computer and information science given by faculty members, outside speakers, and students working on master's theses or projects. The aim of the seminar is to give the student training in making an effective oral presentation on his or her own investigations; and to increase his or her familarity with research areas other than his or her own. Meetings are open to all NJIT students and staff. Seminar fee is equivalent to the cost of one credit hour per semester.

CIS 725, 726, 727
Independent Study in Computer Science I, II, III 3 credits
Prerequisites: graduate standing and department consent.

CIS 730
Seminar in Database Management Topics 3 credits
Prerequisite: CIS 631. A seminar in which students pursue intensive study of specialized topics in the current literature of database management. Each topic is supported by an initial reading list covering current problems in theory and practice. Students present the results of their studies in class with faculty and invited specialists participating. Topics include, but are not limited to, advanced data modeling, object oriented databases, query languages, semantic optimization, database mapping and integration, physical database architecture, database/knowledge-base integration, distributed databases, database machines, database version control, logical and deductive databases.

CIS 731
Applications of Database Systems 3 credits
Prerequisites: CIS 675 and CIS 631. Restricted to students who are specializing in computer and information systems management. Comparative study of different models of database management systems and their applications. Emphasis on the functions of the database administrator. Includes a survey of physical and logical organization of data, methods of accessing data, characteristics of different models of generalized database management systems, and case studies using these systems from various applications. Student teams design database systems for class projects.

CIS 732
Design of Interactive Systems 3 credits
Prerequisites: CIS 675 and CIS 635. Design of interactive systems and human computer interfaces. Covers the current professional literature in this field and the "knowns" about design. Emphasizes application areas that have a great deal of cognitive variability and diverse user populations. Design interfaces for various applications. The impact of costs and operational practices upon user behavior and current research topics in interface design are covered.

CIS 735
Computer Mediated Communication Systems 3 credits
Prerequisite: CIS 675. Seminar for students contemplating research in the following areas: designs and the impact of, computer-based systems for human communication, including electronic mail, computer conferencing, Computer-Supported Cooperative Work (CSCW), Group Decision Support Systems (GDSS), the Internet and the World Wide Web. Topics include alternative design structures, impacts of primarily text-based asynchronous group communication, and recent empirical studies. Completion of a potentially publishable state-of-the-art written review or design of a tailored CMC system is required.

CIS 741
Communication Network Design 3 credits
Prerequisites: CIS 651 and CIS 652. Basic problems of communication network design: analyzes their complexity and provides algorithms, heuristics and other techniques for their solution.

CIS 750
Parallel Processing: Architectures and Programming 3 credits
Prerequisite: CIS 650. An in-depth study of the state of the art of parallel architectures and programming. Topics include, but are not limited to, fundamental issues in parallel computing, shared-memory single-address-space multiprocessors such as Crays and SMPs, distributed-memory message-passing multiprocessors such as IBM SP2, Cray T3D and Fujitsu AP1000+, multithreaded architectures such as ETL EM-X and Tera MTA, Network (cluster) of Workstations (NOWs), introduction to parallelizing compilers, and parallel programming paradigms. Introduces, in class, current and on-going technologies through several laboratory prototype machines, in addition to commercial machines.

CIS 752
Communication Protocol Synthesis and Analysis 3 credits
Prerequisite: CIS 652 or basic familiarity with communication protocols. An in-depth study of the state of the art of protocol engineering. Enables students to apply the techniques of protocol design to real problems in communication protocols.

CIS 754
Measurement and Evaluation of Software Quality and Performance 3 credits
Prerequisites: Ph.D. core courses, CIS 630, CIS 661. A study of the tools for the measurement of software products and the use of these tools in the evaluation of software quality and performance. Structural and functional models of algorithms, programs, and systems are presented to define the quantitative and subjective characteristics of computer products. Course includes the use of hardware and software tools, the study of simulation and analytic techniques, description of workloads and benchmarks for system evaluation, problems of scale, proof of program correctness, feature value analysis, and the design and interpretation of experiments.

CIS 759
Advanced Image Processing and Analysis 3 credits
Prerequisite: CIS 659. Advanced study of recent research in image processing, analysis, and understanding. Topics include all image processing techniques, high-level recognition approaches, and automated expert vision systems.

CIS 762
Computerized Information Systems for Planning and Forecasting 3 credits
Prerequisite: CIS 675. Capturing and processing of subjective and empirical data for use in planning and forecasting information systems and the incorporation of these

facilities into information systems designs. Emphasis on conveying understanding of the limitations of various methods and techniques to meet various planning and forecasting objectives. Use of various techniques such as the Delphi method, structural modeling, cluster analysis and regression approaches.

CIS 767
Computer-Based Decision Systems
3 credits
Prerequisites: Ph.D. core courses, CIS 662, CIS 665. The design, implementation, and utilization of models and their software support systems for application in managerial decision making at the strategic, tactical, and operational levels. Topics include the perspective of decision-support systems, the management of large simulation models and documentation standards, combined hybrid simulation languages and their applications, financial modeling and financial modeling languages. Systems dynamics and its managerial applications at the strategic level; specialized modeling and analysis software packages for managerial decision making; and recent research in computer-aided tools for capturing group judgment, modeling, and decision-making are also discussed.

CIS 775
Seminar in Software Engineering 3 credits
Prerequisite: CIS 673. A seminar in which students pursue intensive study of specialized topics in the current literature of software engineering. Each topic is supported by an initial reading list on current problems in theory and practice. The results of the studies are discussed in class with students, faculty and invited specialists.

CIS 776
Independent Study in Information Systems 3 credits
Prerequisite: restricted to students in the doctoral program in computer science or in management who have a major or minor in computer and information systems in management. Students must have an approved advanced program of study and approval of a faculty advisor to register for this course. Independent study is in a student-selected specialization. Students must present to a field exam committee a "state-of-the-art" review of the specialization topic area.

CIS 777
Seminar in Software Management and Production 3 credits
Prerequisites: Ph.D. core courses. A seminar in which students pursue intensive study of specialized topics in the current literature of software management and production. Each topic is supported by an initial reading list covering current problems in theory and practice. The results of the studies are discussed in class with students, faculty, and invited specialists participating. Topics include, but are not limited to, theory of algorithm structure, analysis of algorithms and programs, hardware technology assessment, automated tools for software production, software measurements and quality, peripheral device interfaces, data communications, computer networks, distributed processing, software verification, implementation standards, documentation standards, system security, software copyright, and project control and organization.

CIS 780
Computer Vision 3 credits
Prerequisite: CIS 659. Intensive study of the construction of explicit and meaningful descriptions of physical objects from computer images. Covers ideas from artificial intelligence, psychology, computer graphics, and image processing.

CIS 785
Selected Topics in Computer and Information Science I 3 credits
Prerequisites: determined by nature of topic area. Advance notice of the topics to be covered is given. This course examines in depth a special interest area of computer and information science. It emphasizes recent work in area selected for the offering of the course.

CIS 786
Selected Topics in Computer and Information Science II 3 credits
Prerequisites: same as for CIS 785. A continuation of CIS 785.

CIS 790
Doctoral Dissertation and Research
Credits as designated
Corequisite: CIS 791. Required for all doctoral students in computer science and for doctoral students in the joint NJIT/Rutgers' doctoral program in management who major in computer and information systems management. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation while engaged in doctoral research. After 30 credits (including 6 credits of CIS 792) are completed, students must register for 3 credits each semester until the dissertation is completed.

CIS 791
Doctoral Seminar Non-credit
Corequisite: CIS 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in computer and information systems management. In the course students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

CIS 792
Pre-Doctoral Research 3 credits
Prerequisite: permission from department chairperson. For students admitted to the doctoral program in computer and information science who have passed the qualifying examination. Research is carried out under the supervision of a designated faculty member. Students identify a research problem and prepare a plan to solve the problem. A maximum of 6 credits of CIS 792 may be applied to the CIS 790 requirement.

CIS 794
Computer Science Colloquium Non-credit
Prerequisite: graduate standing with major in computer science. Colloquium in which national and international experts in the various fields of computer science are invited to present and discuss the results of their recent research.

Economics

Offered by the School of Industrial Management

Econ 565
Managerial Economics 3 credits
Managerial decision-making for different markets: structure of industry, vertical integration, conglomerate firms, multinational firms, theory of "contestable" markets, entry deterrence, estimating demand and cost functions, price discrimination, agency trade, theory of regulation, market signaling and hiring, and theory of share economy.

Electrical Engineering

Offered by the Department of Electrical and Computer Engineering

EE 550
Circuit Analysis 3 credits
Introduction to analysis of linear circuits and systems. Techniques used include mesh and nodal analysis, network theorems, steady-state and transient methods, analogs, Fourier series and transforms, and LaPlace transforms. Pole-zero diagrams are developed as an aid in the study of low-order systems. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

EE 590
BS/MS Co-op Work Experience I
3 credits (additive)
Prerequisites: standing and acceptance in the combined BS/MS program and permission from Department of Electrical and Computer Engineering and Office of Cooperative Education and Internships. Cooperative education/internship providing on-the-job reinforcement of academic programs in electrical engineering. Assignments and projects are developed by the co-op office in consultation with the electrical and computer engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in the ECE department. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

EE 591
BS/MS Co-op Work Experience II
3 credits (additive)
Prerequisites: EE 590 and permission from Department of Electrical and Computer

Engineering and Office of Cooperative Education and Internships. See EE 590 course description. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

EE 592
Co-op Work Experience III
3 credits (additive)
Prerequisites: graduate standing and permission from Department of Electrical and Computer Engineering and Office of Cooperative Education and Internships. See EE 590 course description. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

EE 599
Electrical Engineering Laboratory
3 credits
Prerequisites: B.S. in engineering or science, and permission from ECE department. Workshop on fundamental measurements involving instrumentation commonly used in testing electronic and power circuits. Credits for this course may not be used to fulfill any electrical engineering degree requirement.

EE 601
Linear Systems 3 credits
Methods of linear-system analysis, in both time and frequency domains, are studied. Techniques used in the study of continuous and discrete systems include state-variable representation, matrices, Fourier transforms, LaPlace transforms, inversion theorems, sampling theory, discrete and fast Fourier transforms, and Z-transforms. Computer simulation of linear systems is used, and, where feasible, computer solutions are obtained.

EE 605
Discrete Event Dynamic Systems 3 credits
Corequisite: Math 630 or EE 601 or MnE 603 or equivalent. Covers the theory of discrete event dynamic systems with applications in modeling, control, analysis, validation, simulation, and performance evaluation of computer systems, flexible manufacturing systems, robotic systems, intelligent supervisory control systems, and communication networks. Emphasis on Petri net and automation based approaches.

EE 609
Artificial Neural Networks 3 credits
Prerequisites: EE 601 and EE 673 or consent of instructor. Artificial Neural Networks (ANN) are networks consisting of massively parallel connected simple processing elements arranged in various topology, usually in layers. Various ANN models, learning paradigms, and applications are covered. The course evolves from a simple single-neuron structure to more complex networks.

EE 610
Power System Steady-State Analysis
3 credits
Prerequisite: B.S. in EE or ME. Steady-state analysis of power system networks, particularly real and reactive power flows under normal conditions and current flows under faulty conditions. Symmetrical components and digital solutions are emphasized.

EE 611
Transients in Power Systems 3 credits
Prerequisite: EE 610. Transient performance of power systems with lumped properties, interruption of arcs, restriking voltage, re-ignition inertia effects, switching of rotational systems, magnetic saturation in stationary networks, harmonic oscillations, saturated systems, transient performance of synchronous machines.

EE 612
Computer Methods Applied to Power Systems 3 credits
Prerequisite: undergraduate computer programming. Digital computer techniques proven successful in the solution of power system problems, particularly in the electric utility industry. Emphasis on short-circuit, load flow, and transient stability problems. Matrix sparsity is considered.

EE 613
Protection of Power Systems 3 credits
Prerequisite: EE 610 or equivalent. Coils, condensers, and resistors as protective devices; fundamental principles of protective relaying; relay operating characteristics; power and current directional relays; differential relays; distance and wire pilot relays; heating and harmonic effects.

EE 614
Dynamics of Electromechanical Energy Conversion 3 credits
Prerequisites: EE 620 and undergraduate electric machines. Dynamic behavior of lumped parameter systems; study of a continuum electromechanics, such as magnetic diffusion and the stresstensor; and dynamics of electromechanical continua in two- and three-dimensional systems.

EE 615
Advanced Electromechanical Energy Conversion I 3 credits
Prerequisite: undergraduate electric machines. Steady-state performance of synchronous machines; time constants, sudden reactive loading; sudden short-circuit conditions; dynamic behavior of synchronous machines; speed torque-current control of induction machines; magnetic noise and voltage ripples; and Kron generalized machine theory.

EE 616
Power Electronics 3 credits
Prerequisite: B.S. in electrical engineering. Principles of thyristor devices, dynamic characteristics of choppers, commutation, protection, voltage-fed and current-fed inverter drives, cycloconverters, pulse width modulation, phase control, and microcomputer control, with case studies.

EE 618
Power System Design of Alternative Energy Sources 3 credits
Prerequisite: EE 451 or equivalent (see undergraduate catalog for description). System design modeling, economic feasibility, and applications of alternative and renewable energy sources including: fuel cells, storage batteries, bio-electrochemical cells, redox flow cells, ocean thermal energy converters, and magnetohydrodynamic converters. The modes of system interconnections, including linkage to conventional power systems, are also studied.

EE 620
Electromagnetic Field Theory 3 credits
Prerequisite: undergraduate electromagnetic field theory or equivalent. Maxwell's equations, boundary conditions and formulation of potentials. LaPlace and Poisson equations for electrostatic and magnetostatic problems and the method of images. Dielectric and magnetic materials, force and energy concepts. Quasi-static and time varying fields, plane, cylindrical and spherical waves. Green's functions, transmission lines.

EE 622
Wave Propagation 3 credits
Prerequisite: EE 620 or equivalent. Fundamentals of electromagnetics; radiation and scattering; Green's functions; integral equations; numerical methods; ray optics and asymptotics.

EE 623
Fourier Optics 3 credits
Prerequisite: EE 327 or equivalent. Theoretical background needed to analyze various optical systems: two-dimensional Fourier transforms, vector and scalar diffractions, Fresnel and Fraunhofer approximations, the properties of lenses, coherence theory, frequency analysis of optical imaging systems, spatial filtering, optical information processing, and wavefront-reconstruction imaging.

EE 625
Fiber and Integrated Optics 3 credits
Prerequisites: undergraduate electromagnetic field theory and solid-state circuits. Planar dielectric waveguides, step and graded index fibers and dispersion in fibers. The p-n junction and heterostructures, light emitting diodes and semiconductor lasers, p-i-n and avalanche photodetectors, optical transmitter and receiver designs, optical fiber communication system design concepts.

EE 626
Optoelectronics 3 credits
Prerequisites: undergraduate electromagnetic field theory and solid-state circuits. Optical propagation in anisotropic materials, polarization, birefringence and periodic media. Concepts of electro optics and acousto-optic devices, optical modulators, switches, active filters for optical communication and optical processing.

EE 630
Microwave Electronic Systems 3 credits
Prerequisite: undergraduate course in electromagnetic field theory. Review of transmission line theory and the Smith chart; scattering matrix representation, LC and microstrip matching networks; signal flow graph analysis; microwave transistor amplifier design, which includes power gain, stability, noise figure circles; oscillator design.

EE 632
Antenna Theory 3 credits
Prerequisite: undergraduate course in electromagnetic field theory. Fundamentals of electromagnetic field theory; far field approximation, antenna characteristics (gain, impedence, pattern, etc.); elementary antenna types (dipoles, loops, etc.), antenna array theory, wire antennas; broadband antennas.

EE 635
Conduction in Plasma 3 credits
Prerequisite: undergraduate course in direct power generation. Maxwellian velocity distribution function, concentration and diffusion gradients, mean free path, methods of ionization, field intensified ionization, drift velocity, plasma temperature methods of deionization, plasma oscillations and plasma sheath, spark breakdown and mechanism of arcs.

EE 638
Network Management and Security
3 credits
Prerequisites: CIS 652 or EE 683, and CIS 656. Thorough introduction to current network management technology and techniques, and emerging network management standards. In-depth study of the existing network security technology and the various practical techniques that have been implemented for protecting data from disclosure, for guaranteeing authenticity of messages, and from protecting systems for network-based attacks. SNMP family of standards including SNMP, SNMPv2, and RMON (Remote Monitoring), OSI systems management. Various types of security attacks (such as intruders, viruses, and worms), Conventional Encryption and Public Key Cryptology. Various security services and standards (such as Kerberos, Digital Signature Standard, Pretty Good Privacy, SNMPv2 security facility). *Same as CIS 696.*

EE 639
Principles of Broadband ISDN and ATM
3 credits
Prerequisite: CIS 652 or EE 683 or equivalent. Study of the Broadband Integrated Services Digital Network (B-ISDN) architecture and services. In-depth study of the Asynchronous Transfer Mode (ATM), ATM Adaptation Layer (AAL), ATM switching architectures, SONET/SDH, ATM traffic control, broadband integrated traffic models, Operation Administration and Management (OAM) functions, TCP/IP over ATM, and ATM market. *Same as CIS 697.*

EE 640
Digital Signal Processing 3 credits
Prerequisite: EE 601 or equivalent. The theory of digital signals and basic processing techniques: Discrete Fourier Series, Discrete Fourier Transform and FFT, Linear and Circular Convolution, Digital Filter Design Techniques, Discrete Hilbert Transforms, Discrete Random Signals, Chirp-Z and other advanced transforms. Introduction to multivariate signal processing. The typical applications of signal processing tools are discussed and connected to the theoretical foundations.

EE 642
Communication Systems I 3 credits
Corequisite: EE 673. Principles of communication theory applied to the representation and transmission of information. Topics include analysis of deterministic and random signals, amplitude modulation, angle modulation, sampling, quantization, PCM, DM, DPCM, geometric representation of signals, error probability, matched filter and correlation receivers and performance analysis of communication systems signal to noise ratio.

EE 643
Digital Image Processing I 3 credits
Prerequisite: EE 601. Introductory course in digital image processing. Topics include image models, digitization and quantization, image enhancement in spatial and frequency domains, image restoration, image segmentation and analysis.

EE 644
Introduction to Wireless and Personal Communications Systems 3 credits
Prerequisite: EE 642 or equivalent. Introduces emerging personal communications networks (PCN) and envisioned personal communication services (PCS). Discussion of recent history of underlying technologies that are being used to synthesize PCN and delineation of the alternative approaches being considered. Focuses primarily on U.S. technologies, with coverage of wireless technologies in Europe and Japan.

EE 646
Introduction to Data Communications
3 credits
Prerequisites: EE 642 and EE 673, or equivalent. Introduces the theory and technology of data communications over voice-grade and broadband channels. Provides the analytical tools required to understand and design data communication systems. Topics include: an overview of data communication systems, channel capacity, channel coding (block codes, cyclic codes, convolutional codes), data transmission, synchronization, equalization, and an introduction to adaptive equalization.

EE 648
Digital Microelectronics 3 credits
Prerequisite: undergraduate semiconductor circuits. Topics include: linear wave shaping with RC circuits, clipping and clamping circuits; theory of operation of semiconductor diode, bipolar transistor (BJT), and MOSFET; BJT and MOSFET inverters, gate circuits, and regenerative logic circuits.

EE 649
Compression in Multimedia Engineering
3 credits
Prerequisite: EE 640 or instructor's permission. Foundations in information theory, audio/speech and video compression technologies. Detailed discussion of JPEG, image compression, H.261, MPEG-1 and MPEG-2 international video compression standard algorithms. Current status and future directions of very low bit rate MPEG-4 video compression standards activities.

EE 650
Electronic Circuits 3 credits
Prerequisite: senior undergraduate level semiconductor circuits. Methods of analysis and design of linear and digital semiconductor circuits are studied. Topics include low and high frequency models, passive and active biasing techniques, I-C analysis and design, op-amp circuits, and active filters.

EE 657
Semiconductor Devices 3 credits
Fundamental principles of solid state materials necessary for understanding semiconductor devices. Topics include crystal structure; energy bands; electron and hole generation, and transport phenomena; generation and recombination processes, and high field effects. P-N junction diode, metal semiconductor contact, and bipolar and metal oxide semiconductor transistors, including switching phenomena and circuit models. Introduction to: photonic devices—light emitting diodes, semiconductor lasers, photodetectors, and solar cells; microwave devices—tunnel and IMPATT diodes, transferred electron devices, and charge-coupled capacitors.

EE 658
VLSI Design I 3 credits
Prerequisite: EE 657 or equivalent. Analysis and design of digital integrated circuits; basic building blocks and dependence on circuit parameters of propagation delay; noise margin; fan-out; fan-in; and power dissipation for circuits of different logic families, including NMOS, CMOS and BiCMOS; subsystem designs in combinational and sequential logic; Memory Systems; HSPICE circuit simulation is used for digital characteristics evaluation. Mentor Graphics Layout design tools are used for chip design.

EE 659
Fabrication Principles of Electronic and Optoelectronic Devices 3 credits
Prerequisite: EE 657 or equivalent. Overview of all major processing steps in fabrication of integrated circuits such as crystal growth, epitaxy, oxidation, diffusion, ion implantation and etching. Formation of thin film structures along with techniques for defining submicron structures. Emphasizes silicon device technology but also includes processing of compound semiconductors such as gallium arsenide.

EE 660
Control Systems I 3 credits
Prerequisites: undergraduate course equivalent to EE 333 or ME 305 and EE 601 or equivalent or permission from instructor. Introduction to feedback control. Review of state-space analysis. Frequency-domain methods for analysis: Routh-Hurwitz stability algorithms, Root-loci; Nyquist and Bode plots; system "type." Controlability and observability. The separation principle and design by pole placement. Linear observers. Optimization of quadratic performance criteria. Elements of random processes. The Kalman filter as an optimum observer. Robustness considerations.

EE 661
Control System Components 3 credits
Prerequisite: EE 660. The theoretical and practical requirements for analog and digital state-of-the-art control system components are covered. Actuators, amplifiers, sensors, encoders, resolvers and other electromagnetic devices are included. A complete system is designed using current vendor catalog data. Problems affecting the system performance are analyzed using measures of functionality, reliability and cost.

EE 662
Large Power Control Systems 3 credits
Prerequisites: EE 660, EE 614, or equivalents. Emphasis on the design and test analysis of servomechanisms and regulation systems involving large power components such as dc machines, induction motors, and alternators. Positioning and velocity servos using rotating amplifiers are covered. A velocity servo for controlling a large induction motor is designed and a typical alternator voltage regulator studied, with regard to its servo characteristics. Methods of determining motor size and gear ratio in large positioning servos are covered.

EE 664
Real-time Computer Control Systems
3 credits
Prerequisite: EE 486 or equivalent. Emphasizes the practical aspects of modern computer control systems. Topics include: Architecture of digital signal processors (DSP) and microcontrollers, real-time data acquisition devices and interface, programming a DSP, review of sampling theorems and properties of discrete-time systems, introduction of control systems theory, design and implementation of parameter optimized controllers, state variable controllers, and cancellation controllers. An experimental project using a TMS320C2x DSP-based data acquisition system is an integral part of this course.

EE 666
Control Systems II 3 credits
Prerequisites: EE 601 and EE 660. Properties of nonlinear systems and basic concepts of stability including small-signal linearization. State plane methods are introduced, with emphasis on controller design for systems that can be represented by second-order approximations. Concepts of equivalent gain, describing function, and dual-input describing function as applied to a large class of nonlinear systems. Representation of linear sampled-data systems in discrete state variable form—stability and performance of discrete-event systems. Full-state feedback, pole placement and observer design. Linear quadratic control and Kalman filtering.

EE 667
Systems Studies in Bioengineering
3 credits
Prerequisite: Undergraduate or graduate course in linear systems. Basic techniques of simulation including digital simulation languages. Physiologic systems of current interest using systems analysis techniques leading to formulation of mathematical, digital computer, or electric circuit models. Systems examined include the circulatory, respiratory, or hormonal control systems. Basic techniques of signal processing are explored which are necessary to analyze data from physiologic systems.

EE 673
Random Signal Analysis I 3 credits
Fundamentals of the theory of random variables. Introduction to the theory of random processes. Topics include functions of random variables, sequences of random variables, central limit theorem, properties of random processes, correlation, spectral analysis and linear systems with random inputs.

EE 677
Optimization Techniques 3 credits
Prerequisite: undergraduate course in differential equations. Analytical and numerical methods for finding an extremum emphasizing how and when to apply them. Classical differentiation, Lagrange multipliers, the calculus of variations, penalty functions, slack variables, search techniques, and stochastic approximation are covered.

EE 683
Computer Network Design and Analysis
3 credits
Corequisite: EE 673. Queueing models and state-transition models are introduced to model, design and analyze computer networks. The OSI model, LANS (including token ring, token bus, and Ethernet), and useful network protocols. Emphasis on the physical, data link and network layers. ALOHA, Stop-and-Wait protocol, Go-Back-N protocol, window-flow-control, and shortest-path routing.

EE 684
Advanced Microprocessor Systems
3 credits
Prerequisites: undergraduate course in computer architecture and microprocessors, and some experience in assembly language programming. Architecture of advanced microprocessors; CPU architecture, memory management and protection, interrupt and exception facilities, instruction sets, systems aspects including peripheral interfaces, communications ports, and real-time systems.

EE 686
Instrumentation Systems and Microprocessors 3 credits
Prerequisite: undergraduate course in microprocessors. Principles of instrumentation transducers and the electronic amplifiers and filters needed to process the electrical signals generated by them; types and characteristics of A/D and D/A converters and other circuits necessary for the interfacing of instrumentation data to a digital computer or digital data transmission system. Emphasis placed on development of stand-alone analog instrumentation systems as well as microprocessor-based systems. Tradeoffs and alternatives for both implementations are emphasized as well as cost effectiveness of each design. Hardware and software are developed as needed.

EE 687
Design of Medical Instrumentation
3 credits
Prerequisite: Undergraduate course in electronics. Principles and practice of medical instrumentation. Instrument components and medical instrument systems design. Examples taken from electrocardiography, clinical chemistry, medical imaging. Microprocessor-based systems emphasized.

EE 688
Microcontrollers in Instrumentation
3 credits
Prerequisite: undergraduate course in microprocessors. Microcontroller as single chip computer system for diverse applications. System microcontroller real-time design concepts from architecture to interface. Assembly language programs. Real-time facilities of advanced microcontrollers are emphasized.

EE 689
Digital System Design for Machine Arithmetic 3 credits
Prerequisite: undergraduate course in logic design. Data representation, integers, floating point and residue representation. Bounds on arithmetic speed, algorithms for high speed addition, multiplication, and division. Pipelined arithmetic. Hardware implementation and control issues.

EE 690
Computer Systems Architecture 3 credits
Prerequisites: EE 684 and CoE 353 (see undergraduate catalog for description) or CIS 650. Discusses advanced topics in modern computer systems architecture such as pipelined and superscalar processors, parallel computers (vector, SIMD, MIMD), multithreaded and dataflow architectures, cache and memory hierarchy, and system interconnect architectures. Also discusses relevant system software design issues such as shared memory and message-passing com-

munication models, cache coherence and synchronization mechanisms, latency-hiding techniques, virtual memory management, program partitioning and scheduling. Examples are drawn from real systems. *Same as CoE 651.*

EE 698
Selected Topics in Electrical Engineering 3 credits
Special area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

EE 699
Selected Topics in Electrical Engineering 3 credits
See description for EE 698 above.

EE 700
Master's Project 3 credits
Prerequisite: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Cooperative projects with industry may be acceptable. Work is carried out under the supervision of a member of the department faculty. A maximum of 3 credits may be applied to the degree.

EE 701
Master's Thesis 6 credits
Prerequisite: written approval of thesis advisor. Projects involving design, construction, experimental or theoretical investigation. Cooperative projects with industry or governmental agencies may be acceptable. Work is carried on under the supervision of a designated member of the department staff. Completed work in the form of a written thesis should merit publication in a technical journal. The completed thesis must be defended by the student in an open forum and must be approved by a committee of at least three people. A student must register for a minimum of 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

EE 710
Economic Control of Interconnected Power Systems 3 credits
Prerequisite: EE 610. Theoretical developments and computer methods in determining economic operation within the boundaries of a given steam-electric operating area. Energy accounting control and economic theories for interconnected steam and hydro-electric power systems.

EE 711
Power System Dynamics and Stability 3 credits
Prerequisites: EE 610 and undergraduate course in electric machines. Elements of the stability problem: principal factors affecting stability, ordinary simplified methods of making stability calculations, and illustrations of the application of these methods to studies of power systems, damping, and saturation.

EE 719
Advanced Electromechanical Energy Conversion II 3 credits
Prerequisites: EE 615, EE 622. Derivation of circuit models of rotating systems, based on the cross-sectional space wave method and the study of generalized Maxwell-Lorentz equations, applied to coupled rotational bodies.

EE 725
Independent Study I 3 credits
Prerequisite: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count EE 725 as degree credit but can count these credits to qualify for full-time status.

EE 726
Independent Study II 3 credits
See description for EE 725 above. This course is not available to master's students.

EE 727
Independent Study III 3 credits
See description for EE 725 above. This course is not available to master's students.

EE 730
Theory of Guided Waves 3 credits
Prerequisite: EE 620 or equivalent. Modes, rays and beam propagation in guiding structures. Non-uniform waveguides and transitions, excitation of waveguides and optical fibers. Coupled modes theory with applications to resonators and couplers. Wave propagation in anisotropic media.

EE 736
Introduction to Quantum Field Theory 3 credits
Prerequisites: EE 622, Phys 633. Special relativity, four-dimensional formulation of electrodynamics, quantum theory of electromagnetic fields, second quantization, and interaction of radiation and discrete energy level systems.

EE 739
Laser Systems 3 credits
Prerequisite: EE 620 or permission of instructor. Optical resonators, laser radiation and oscillation. Laser characteristics: semiconductor lasers, gas and glass lasers; mode-locking, Q-switching. Quantum-well lasers, noise; modulation and detection of laser light, optical systems for communication and computation.

EE 740
Advanced Digital Signal Processing 3 credits
Prerequisites: EE 601, EE 640 and EE 673. Topics in stationary discrete time stochastic processes; modeling of discrete time processes, Yule-waker equations, aspects of discrete wiener theory; principle of orthogonality, linear predictors; Levinson-Durbin recursion and algorithm, lattice predictors, method of least squares (RLS) algorithm, systolic array implementation of QRD-Ls.

EE 742
Communication Systems II 3 credits
Prerequisites: EE 642 and EE 673 or equivalents. Principles of digital communication. Topics include fundamentals of information theory, digital modulation techniques, optimum detector receivers for digitally modulated signals, the bandlimited gaussian channel and intersymbol interference, equalization, spread spectrum, CDMA.

EE 744
Communication Systems Design 3 credits
Prerequisite: EE 642 or equivalent. Theory and principles of analog and digital communication systems design. Topics will be selected from: point-to-point microwave, satellite, random access, spread spectrum, cellular system and other systems of interest.

EE 746
Adaptive Array Processing and Interference Cancellation 3 credits
Prerequisites: EE 642 and EE 673. Principles of array processing, performance criteria used, and adaptive algorithms for realization of these processors; and ideas and principles of array processing in the design of contemporary radar systems.

EE 747
Signal Decomposition Techniques: Transforms, Subbands, and Wavelets 3 credits
Prerequisites: EE 640 and EE 673. Multiresolution signal decomposition techniques—transforms, subbands, and wavelets. Time-frequency localization properties of multiresolution algorithms. Evaluation and critique of proposed decomposition strategies from compression and performance standpoints. Applications to speech and video compression, and localized feature extraction. These are basic signal processing tools used in diverse applications speech and image processing and storage, seismology, machine vision.

EE 755
Advanced Topics in Digital Communication 3 credits
Prerequisites: EE 642 and EE 673 or equivalent. Advanced topics in digital communication systems in the presence of intersymbol interference, noise, and fading: modulation and demodulation in the presence of gaussian noise, efficient signaling with coded modulation, trellis decoding, Viterbi algorithm, digital transmission with intersymbol interference, and digital signaling over imperfect channels.

EE 757
Wireless Communications 3 credits
Prerequisite: EE 742 or equivalent. Introduction of digital cellular radio. In-depth analytical characterization of linear, time-variant systems as they apply to wireless channels. Thorough consideration of the principles of the CDMA multiuser system, together with methods for reducing multiple-access interference. Emphasis on general topics such as diversity interleaving.

EE 758
VLSI Design II 3 credits
Prerequisite: EE 658 (with EE 657 Suggested). Use of CMOS, biCMOS and bipolar semiconductor technology for VLSI design. Digital techniques are emphasized with minor coverage of analog design. Application areas for full custom, gate arrays, standard cell, and compiled designs are compared. Mentor VLSI design tools running on the HP and Sun workstations are used in the course projects for each enrollee. The course attempts to provide a design environment for projects that is similar to that encountered by VLSI designers in industry.

EE 759
Principles of Phase Lock and Frequency Feedback 3 credits
Prerequisites: EE 642 and EE 673 or equivalents. Principles of operation and design for phase locked and frequency feedback loops, linear equivalent circuit, nonlinear effects, and optimization against noise used in a wide range of applications including low-level signal reception, tracking, phase extraction, filtering, and frequency synchronization. F.M. communication is emphasized.

EE 760
Solid-State Image Sensors 3 credits
Prerequisites: EE 657 and EE 648 or EE 658. Construction, operation, and performance evaluation of visible and infrared image sensors. Included are a review of the main approaches for photodetectors and readout structures, image sensor architectures, performance evaluation and trade-offs, noise considerations, modulation transfer function, techniques for control of blooming, interlacing, colorcoding for visible imagers, HDTV imagers, photo-counting amplifiers, and radiometry and figures of merit for infrared imagers.

EE 766
Stability Theory of Nonlinear Systems 3 credits
Prerequisite: EE 666. Concepts of stability in dynamic systems, theory and application of Lyapunov's direct method. Use of functional analysis, and frequency response method of Popov and its extensions including their application to the investigation of stability, boundedness, and damping in a class of unforced and forced nonlinear systems.

EE 768
Optimal Control Theory 3 credits
Prerequisite: EE 677. Optimal control for classes of deterministic systems with various constraints using calculus of variations, dynamic programming and the maximum principle, state variable constraints, and application of theory to design problems.

EE 769
Stochastic Estimation and Control 3 credits
Prerequisites: EE 660 and EE 673. Markov processes. The discrete-time Kalman filter as a minimum variance estimator. The continuous-time Kalman-Bucy filter. Relationship to the Wiener filter. Nonlinear systems: the extended Kalman filter and other generalizations. Computational difficulties and methods for avoiding them: separated-bias estimation, "UDU" factorization. Applications in navigation and control.

EE 773
Random Signal Analysis II 3 credits
Prerequisite: EE 673. Continuation of EE 673. Non-stationary stochastic processes, harmonic analysis, the zero crossing problem, Markov processes, the Poisson process, orthogonal expansions, non-Gaussian processes, non-linear operations.

EE 776
Information Theory 3 credits
Prerequisites: EE 642 and EE 673 or equivalents. Classical theory of information developed from Shannon's theory. Information measure, Markov sources and extensions, the adjoint source, uniquely decodable and instantaneous codes and their construction, Shannon's first and second theorems, mutual information, and performance bounds on block and convolutional codes.

EE 777
Statistical Decision Theory in Communications 3 credits
Prerequisite: EE 642 or equivalent. Relation between detection theory and statistical hypothesis testing problem. Use of Bayes decision criteria, Neyman-Pearson, and minimax tests; receiver operating characteristics. Representation of signals in signal space, probability of error calculations. Estimation of random and non-random signal parameters, Cramer-Rao Inequality. The general Gaussian problem and the use of covariance matrices.

EE 778
Algebraic Coding for Information Transmission 3 credits
Prerequisites: EE 642 and EE 673. Coding for reliable digital transmission and storage, error detection and correction codes. Decoding techniques and performance evaluation of block and convolutional codes, including BCH, Reed-Solomon code and Trellis coded modulation.

EE 783
Computer Communication Networks 3 credits
Prerequisites: EE 673 and EE 683. Data link control and communication channels. Delay models in data networks. Queueing analysis techniques are taught in detail. Multi-access communication techniques. Routing in computer communication networks.

EE 785
Parallel Processing Systems 3 credits
Prerequisite: EE 684 or equivalent. A variety of real-time applications require increased computational power. A large number of projects have focused on the design and development of high-performance systems that could provide a quantum increase of computational speed over conventional systems. This course investigates the appropriateness of various architectural characteristics of parallel processing systems for significant classes of application algorithms. Techniques for mapping application algorithms onto such systems and the development of parallel algorithms are also discussed. The incorporation of tradeoffs into the design of parallel processing systems is covered, based on performance evaluation techniques.

EE 788
Selected Topics in Electrical Engineering 3 credits
Special-area course given when suitable interest develops. Advance notice of forthcoming topics will be given.

EE 789
Selected Topics in Electrical Engineering 3 credits
See description for EE 788 above.

EE 790
Doctoral Dissertation and Research
Credits as designated
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

EE 791
Graduate Seminar 1/2 credit
Required each semester of all doctoral students and master's students receiving departmental and research-based awards. To receive a satisfactory grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

EE 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of the department. For students admitted to the program leading to the degree of Doctor of Philosophy in Electrical Engineering. Research carried on under the supervision of a designated member of the department faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under EE 790 after the student fulfills requirements of doctoral candidacy.

EE 793
Professional Project Credits as designated Required of all candidates for the Degree of Engineer. A minimum of 12 credits is required. The student must register for at least six credits of professional project per semester until completion of 12 credits. If the student is still actively engaged in the preparation of the project after completion of 12 credits, continued registration of three credits per semester will be required.

Engineering Management

Offered by the Department of Industrial and Manufacturing Engineering

EM 501
Industrial Management 3 credits
Prerequisite: approval from the engineering management graduate advisor or program director. Operational aspects of management techniques: organization, product design and development, distribution logistics, marketing, plant location and layout, materials handling, production planning and control, inventory control, quality control, work analysis, and incentive plans.

EM 502
Engineering Cost Analysis 3 credits
Prerequisite: approval from the engineering management graduate advisor or program director. Financial, engineering, economic, and cost-control aspects of industrial management; the accounting cycle; cost accounting procedure; and cost-model techniques of making cost comparisons through engineering economic studies.

EM 503
Methods and Applications of Industrial Statistics and Probability 3 credits
Prerequisites: approval from the engineering management graduate advisor or program director, undergraduate course in calculus. An analytical approach to basic engineering probability and statistics, with applications drawn from both manufacturing and process industries. Emphasis is placed upon the utility of statistical inference derived from engineering data.

EM 602
Management Science 3 credits
Prerequisites: undergraduate calculus and probability and statistics. Linear programming: formulation, methodology, and application; the transportation problem; the assignment problem; Markov chains and their applications in decision making; queueing systems; deterministic and stochastic inventory models.

EM 607
Seminar in Contemporary Management Problems 3 credits
Prerequisites: undergraduate courses in economics and management. Readings, discussions, field studies, and reports in areas of contemporary management, behavioral science, management science, economics, and systems planning and control. Course is designed to encourage and give direction to student research for thesis.

EM 617
Environmental Risk Assessment 3 credits
Prerequisites: undergraduate courses in calculus and economics. Application of management technique methodology to recognize, evaluate, and make decisions regarding expenditures for the mitigation of potentially hazardous environmental risks. Basic analytical techniques applicable to social and economic risk assessment; methodology and application to current air and water resources; and rationale for cost-benefit and trade-off analysis. Technical characteristics of materials: half-life, decomposition rates, and temperature sensitivity determining environmental probabilities and expectations.

EM 631
Legal Aspects in Environmental Engineering 3 credits
Control of air, water, and solid waste pollution by federal, state, and local government statutes and international law. Preparation of environmental impact statements and the right of private citizens to bring suit under federal clean air and water pollution legislation are discussed, as well as limitations on these rights.

EM 632
Legal Aspects in Construction 3 credits
Introduction to the legal factors affecting construction activities: contract responsibilities of contractors, engineers, and owners; subcontracts and third-party liability; construction law and code compliance; and insurance and bonds.

EM 633
Legal Aspects of Health and Safety 3 credits
Review of key laws and regulations to occupational health, safety, and product liability; methods to determine which codes apply in given situations and to prepare operating procedures to be used for internal compliance.

EM 634
Legal, Ethical and Intellectual Property Issues for Engineering Managers 3 credits
Introduction to various environmental, product liability, health and safety, and intellectual property, legal, as well as ethical, issues facing engineering managers. Current New Jersey and federal laws and pending legal actions in these fields. Case studies and advanced multimedia learning tools are used.

EM 635
Management of Engineering Research and Development 3 credits
Prerequisites: principles of management and statistics, or EM 501 and EM 503. A systems approach to management of resources, and tasks needed for engineering research and development. Identification, analysis, and evaluation of the operational characteristics and structure of the research laboratory and engineering office; functions of planning, organizing, staffing, direction, control, innovation, and representation; and planning and control theories, techniques, and current practices in scientific and engineering management.

EM 636
Project Management
Prerequisites: IE 492, IE 603 or equivalents. Introduction to concepts of project management and techniques for planning and controlling of resources to accomplish specific project goals. While the focus is on technically oriented projects, the principles discussed are applicable to the management of any project. Topics include time, cost considerations, cash flow forecasting, financial and performance control, documentation.

EM 637
Project Control 3 credits
Prerequisite: EM 636 or equivalent. Focuses on the methodology that can be employed to plan project implementation and control progress. Topics include work breakdown construction, task and schedule development budgetary control, earned value analysis, and behavioral considerations. Project management software utilization is emphasized.

EM 640
Distribution Logistics 3 credits, 2nd sem.
Prerequisite: EM 602 or Tran 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. *Same as Tran 640.*

EM 641
Engineering Procurement and Materials Management 3 credits, 1st sem., summer
Prerequisites: EM 602, EM 640, and EM 674 or equivalents. Study of the logistics life cycle, involving planning, analysis, design, testing, distribution and life cycle support. Make versus buy engineering design decision. Various tools and techniques for an effective life cycle support program. Benchmarking approach to survey available internal and external resources and competitor solutions. Constructing life cycle cost models for acquisitions. Build adequate specification. Application of the latest techniques in supplier chain quality management. Case studies and advanced multimedia learning tools are used.

EM 655
Management Aspects of Information Systems 3 credits, 1st and 2nd sem.
Prerequisite: computer programming experience. Information flow in an organization as an integrated system and management resource: techniques of data analysis, design, and processing; characteristics of computerized information-handling equipment; data acquisition, storage, processing, retrieval, and transmission to decision-makers; and information systems for finance, production, inventory, accounting, marketing, and distribution.

EM 660
Financing an Industrial Enterprise
3 credits, 2nd sem.
Prerequisites: undergraduate economics, accounting, and engineering economy. Principles of financial practice and management in modern business corporations emphasizing financial planning and control; capital project and working capital needs; internal and external financing; and finance as a major function of the management process.

EM 661
Advanced Engineering Economics
3 credits
Prerequisite: undergraduate engineering economics or equivalent. Economic use of a firm's capital resources. Feasibility studies of potential major capital investments likely to be considered by an enterprise. Risk assessment, cost engineering, effect of financing sources, life cycle, and technologies forecasting models. Case studies are used.

EM 674
Benchmarking and Quality Function Deployment 3 credits
Prerequisite: IE 673 or equivalent. Continuation of IE 673. Benchmarking surveys of competition, process analysis of engineering activities, statistical process control mathematics, Taguchi methods of process and product design, current total quality management innovations, quality functional deployment. Case studies and advanced multimedia learning tools are used.

EM 691
Cost Estimating for Capital Projects
3 credits
Prerequisites: EM 502 and EM 503, or equivalent. Cost estimating techniques and procedures for budgeting used in evaluation, planning, and control of capital investments. Emphasis on updating for change, escalation, and statistical and computer methods.

EM 693
Managerial Economics 3 credits
Prerequisite: undergraduate economics. Internal and external influences on the economic practices of business; classical and current theories of economic behavior; contemporary analytical techniques; behavior of costs, prices, and profits; demand analysis, competition and monopoly; capital expenditure planning; profit theories and business cycles; and econometric models of market strategies, competitive action, and demand behavior.

EM 695
Public Utility Energy Management
3 credits
Prerequisite: EM 602 or equivalent. Managing loads on electric power systems. Influence of variable rate structure and description of several projects currently in progress.

EM 696
Nuclear Power Reactor Management
3 credits
Prerequisites: undergraduate economics and physics. Nuclear power reactor management and power generation alternatives: optimum performance; maximum control; minimum cost; capacity planning; cost estimating; investment requirements; plant location and safety; separation technology for fuel enrichment; transportation and storage of spent fuel; reprocessing and nuclear waste storage; and regulatory aspects of nuclear power. Offered alternate years.

EM 701
Master's Thesis 6 credits
Prerequisites: matriculation for the M.S. degree, adequate graduate courses in the field of the proposed thesis, and the thesis advisor's approval. Thesis must contribute to the field, and preferably aid the candidate's present or potential career. While original research may not always result, the thesis should provide a new conclusion or application. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

EM 714
Multicriteria Decision Making 3 credits
Prerequisite: some background in operations research. Multiobjective programming and conflict analysis to evaluate alternatives in decision making, utility, assessment methodology, interactive and noninteractive multiple mathematical programming methods, and surrogate worth trade-off methods are covered.

EM 715
Design of an Enterprise 3 credits
Prerequisites: undergraduate economics, industrial management accounting, engineering economy, probability and statistics; 9 credits of EM courses at 600-level or above; and advisor's approval. Organization and management of an enterprise, from initial planning through production and distribution of manufactured products. Students choose the industry that they study.

EM 716
Seminar in the Design of an Enterprise
3 credits
Prerequisite: EM 715. Continuation of EM 715. Depending on the student's interest, report on design of the particular enterprise emphasizing either the management of research and development; the management of production; the management of distribution; or the management of manpower.

EM 725
Independent Research 3 credits
Prerequisite: permission from the ME department's industrial and management engineering division advisor. Program of study prescribed and approved by student's advisor. Special course covers areas of study in which one or more students may be interested, but is not of sufficiently broad interest to warrant regular course offering.

EM 740
Management of Transportation Carriers
3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Presents theory and practice of managing transportation carriers, including the concepts of costing, pricing, designing and marketing transportation service; the concepts of financial efficiency and resource productivity with application to the selected freight carriers in each mode of transportation. Selected case studies of carriers' operations management practices in various modes. Comparative studies of service characteristics, market share, cost structures both within a particular transportation mode and between the modes. *Same as Tran 740.*

EM 765
Multi-Modal Freight Transportation Systems Analysis 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as Tran 765 and CE 765.*

EM 771
Operations Cost and Management Control
3 credits
Prerequisites: 6 credits of EM courses at 600-level or above. Analysis and control of cost and other operational aspects of enterprises: manufacturing, distribution and overhead budgets; cost accounting; management information systems; relevant behavioral factors; financial and other management reports. Case studies used.

English

Offered by the Department of Humanities and Social Sciences

Eng 541
Advanced Technical and Research Report Writing 3 credits
Prerequisite: proficiency in English. Designed for graduate students whose curricula require the writing of research and technical papers. Covers the process of planning reports and methods of research, including computer-aided searching for information, systems of documentation, work processing, data organization and presentation, and effective communication techniques.

Eng 571
Technical Writing
For students in the MS Interdisciplinary Studies program.

Eng 601
Advanced Professional and Technical Communication 3 credits
Provides the foundation for all Professional and Technical Communication coursework. Using principles of modeling and cognitive apprenticeship, faculty from both academic and corporate communities show the cognitive and metacognitive processes that comprise their expertise as they solve communication problems. Modules include ethics, oral presentations, research, editing, collaboration and interpersonal skills, and rhetorical analysis.

Eng 603
Cultural and Technological Change 3 credits
Examines the complex ways in which technology constructs and is constructed by society, with special emphasis on the interrelationships between technology and communication. Discussions focus on how technological change is expressed in social and political movements, literature, art, architecture, and philosophy and how they, in turn, influence the future direction of technology.

Eng 604
Communication Theory 3 credits
Builds on an understanding of rhetorical theory and explores a range of contemporary communication theories: theories of meaning, discourse, persuasion, cognition, and social contextualism. Emphasis is on exploring theories of communicative action in order to critique communicative practice.

Eng 605
Document Design and Desktop Publishing 3 credits
Provides an understanding of and capability in the visual presentation of information. Course integrates theories of design, principles of layout and format, and technology of desktop publishing. Modules include theory and practice in design and information processing, design and visual coherence, visual aspects of documents, tools of design, and production and integration of graphics into documents.

Eng 611
Research Methods in Professional and Technical Writing 3 credits
Prerequisite: Eng 601. Allows students to understand and perform research in the four major traditions in professional and technical writing. Students analyze case studies and write brief research papers in the historical, the theoretical, the cognitive, and the empirical traditions. In addition, students write a final paper for publication in a professional journal or a proposal for the thesis.

Eng 613
Multimedia Presentations 3 credits
Prerequisite: Eng 605 or equivalent. Builds on the foundational work of Eng 605 and prepares students to work across electronic media in communicating and presenting professional and technical information. Focuses on communication concepts and problem-solving using practical techniques that combine text, audio, graphics, and video.

Eng 620
Proposal Writing 3 credits
Provides an understanding of and practice in proposal writing for corporations, foundations, and government agencies. Builds skills to create a range of persuasive documents including proposals for research grants, responses to requests for proposal, and government proposals.

Eng 622
Collaborative and Interpersonal Communication 3 credits
Uses a case-study approach to give both the theoretical foundations and the hands-on practice needed to work effectively in and among heterogeneous corporate groups. Includes collaborative writing, interviewing, and conflict resolution.

Eng 624
Professional and Technical Editing 3 credits
Presents the theory and practice of editing professional and technical writing. Topics include correctness and conciseness, hard copy and on-line editing, editing graphics, document management, editor-author relationships, and ethical considerations in editing. Students edit writing samples from a variety of technical fields.

Eng 642
Professional Writing 3 credits
Introduction to technical writing and executive communications for corporate and business markets. Includes global communication and modern organizational culture.

Eng 700
Project in Professional and Technical Communication 3 credits
Prerequisites: approval of graduate advisor, and completion of core courses and independent study related to project. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. Based on experiential research (internship, coop, work experience). In consultation with graduate advisor, student selects a Project Committee, which consists of program-approved faculty advisor and external reviewer.

Eng 701
Thesis in Professional and Technical Communication 6 credits
Prerequisites: approval of graduate advisor; completion of core courses. Demonstrates ability to conceive and execute an extended writing project with professional graphics and to make an oral and visual presentation of the work. The completed written thesis should warrant publication in a technical journal. Thesis Committee consists of program-approved faculty advisor, one other faculty member, and external reviewer. A student must register continuously for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited to 6 credits.

Eng 725
Independent Study in Professional and Technical Communication 3 credits
Prerequisite: approval of graduate advisor and supervising faculty. Allows development of areas of specialization for Master's Project or for program. Areas of study in communication in which one or more students may be interested, but which are not of sufficiently broad interest to warrant a regular course offering.

Eng 791
Graduate Seminar Non-credit
Faculty, students, and invited speakers present summaries of advanced topics in technical and professional communication. Discussion of research procedures and thesis/project organization. Required of all students receiving departmental or research-based awards.

English as a Second Language (ESL)

Offered by the Department of Humanities and Social Sciences

Eng 500, Eng 502, and Eng 505 meet for 10-week intensive sessions, beginning the third week of each semester. Eng 503 and Eng 507 are on a regular schedule.

Eng 500
English for International Graduate Students I 3 credits
Practice in listening and conversational English for students whose native language is not English.
Level: Low Intermediate

Eng 502
English for International Graduate Students II 3 credits
Practice in writing strengthens sentence structure, grammar, vocabulary, and organization. For technical writing, see Eng 541.
Level: High Intermediate

Eng 503
Advanced English for International Teaching Assistants 3 credits
Practice in public speaking for international TA's and other international students who want to improve their oral presentation skills. Also covers teaching techniques and pronunciation.
Level: Advanced

Eng 505
Advanced Spoken English for International Graduate Students 3 credits
Designed to improve English pronunciation; accent reduction.
Level: Advanced

*Eng 507
Advanced Conversation and American Culture 3 credits
Practice in conversation in English at an advanced level. The goal is to help students gain the cultural knowledge and speaking skills for fuller participation in American life.
Level: Advanced

Environmental Engineering

Offered by the Department of Civil and Environmental Engineering

EnE 560
Chemistry for Environmental Engineers 3 credits
Prerequisite: undergraduate general chemistry. Basic physical and chemical principles applied to environmental and sanitary engineering.

*pending

EnE 660
Introduction to Solid and Hazardous Waste Problems 3 credits
Prerequisite: EnE 560. (May be taken concurrently.) Introduction to solid waste disposal. Industrial and urban sources of solid waste and conventional methods of waste disposal. Application of engineering principles related to these topics.

EnE 661
Microbiology for Environmental Engineers 3 credits
Prerequisite: EnE 560. (May be taken concurrently.) Biological and microbiological principles applied to environmental and sanitary engineering. Bacteriological examinations in the laboratory of water and wastewater.

EnE 662
Site Remediation 3 credits
Prerequisite: EnE 560 or EvSc 610 (may be taken concurrently), EM 631 suggested. Examines site remediation from start to finish. Includes regulations, cleanup standards, remedial investigations, feasibility studies, risk assessment, and safety. Examines established and innovated cleanup technologies such as incineration, containment, bioremediation, vapor extraction and ground water recovery.

EnE 664
Physical and Chemical Treatment 3 credits
Prerequisite: EnE 560. Physical and chemical operations and processes employed in the treatment of water and wastewater. Topics include gas transfer, coagulation, flocculation, solid-liquid separation, filtration, and disinfection.

EnE 665
Biological Treatment 3 credits
Prerequisites: EnE 560, EnE 661. (May be taken concurrently.) Principles of evaluation and control of water pollution that describe aerobic treatment processes: oxidation ponds, trickling filters, and activated sludge. Anaerobic digestion and sludge handling and disposal as well as biodegradability study techniques for various wastes.

EnE 666
Analysis of Receiving Waters 3 credits
Prerequisites or corequisites: EnE 560 and EnE 661. Ecological responses of various types of receiving waters to municipal and industrial waste loadings. Mathematical models for water quality prediction and planning.

EnE 667
Solid Waste Disposal Systems 3 credits
Prerequisite: EnE 560. Review and evaluation of design criteria, methods, and equipment employed in handling and disposal of industrial and municipal solid wastes. Emphasis is on hazardous toxic waste, resource recovery, and regulatory constraints (RCRA, TDSCA, etc.).

EnE 668
Air Pollution Control 3 credits
Prerequisite: EnE 560 or physical chemistry. The nature of air pollution, its effect on the public, and legal and engineering remedies.

EnE 669
Water and Wastewater Analysis 3 credits
Prerequisites: EnE 560, EnE 661. (May be taken concurrently.) Measurement of parameters of interest in water and wastewater quality studies is performed in the laboratory. Specific project requiring analysis, interpretation, and recommendations will be a major part of the work.

EnE 670
Advanced Processes in Water Pollution Control 3 credits
Prerequisite: EnE 669. Detailed laboratory experiments using unit operations of sedimentation, coagulation and flocculation; chlorination, filtration, aeration, sludge treatment and digestion. Aspects of pilot plant design and layout are considered. Design parameters discussed in prerequisite courses are developed by advanced bench-scale laboratory procedures. Advanced design and synthesis are considered.

EnE 671
Environmental Impact Analysis 3 credits
Prerequisite or corequisite: EnE 560. A graduate course dealing with physical aspects of the environment. Overview of environmental problems, federal and state standards, methodology for developing impact statements, case studies based on recent experience, basis for assessment and decision making.

EnE 700
Environmental Engineering Projects 3 credits
Prerequisite: student must have sufficient experience and/or graduate courses in major field to work on the project. Subject matter to be approved by the department. Permission to register must be obtained from the project advisor. Extensive investigation, analysis, or design of environmental engineering problems not covered by regular graduate course work is required. A student with an exceptional project in EnE may, upon his/her own initiative and with the approval of his/her advisor, substitute the work of this course as the equivalent of the first 3 credits for EnE 701 Master's Thesis.

EnE 701
Master's Thesis 6 credits
The thesis is to be prepared on a subject in the student's major field approved by the department. Approval to register for thesis must be obtained from the thesis advisor. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated for the thesis.

EnE 702
Special Topics in Civil and Environmental Engineering 3 credits
Prerequisite: advisor's approval. Topics of special current interest in civil and environmental engineering. This course may be taken as an independent study with a faculty advisor, with permission of the department chair.

EnE 725
Independent Study I 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

EnE 726
Independent Study II 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

EnE 727
Independent Study III 3 credits
Prerequisite: written permission from department chairperson plus courses to be prescribed by the supervising faculty member. Covers areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering.

EnE 760
Applied Environmental Soil Chemistry
3 credits
Prerequisites: EnE 560, Math 651 or equivalent. Understanding of physical and chemical processes occurring in soils as well as the chemical and physical properties of subsurface soil environments. Emphasizes current research of the subsurface environment.

EnE 790
Doctoral Dissertation and Research
Credits as designated
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student has not completed the dissertation after completion of 36 credits, continued registration of 3 credits per semester is required.

EnE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Students and faculty discuss research procedures, thesis organization, and content. Students present their own research for discussion and criticism. Required of all doctoral students registered for EnE 790 unless requirement is waived, in writing, by the Dean of Graduate Studies.

Environmental Policy Studies

Offered by the Department of Humanities and Social Sciences

EPS 506
Technology Assessment 3 credits
Prerequisites: undergraduate courses in economics and calculus or statistics. Impact of technology on society in the present and future in terms of economic, social, and environmental factors. Multi-disciplinary approach using analytical techniques for evaluation and forecasting (i.e., cost-benefit analysis and cross impact matrices).

EPS 511
Economics of Energy 3 credits
Trends in patterns of energy use and future prospects; international aspects; energy supply; alternative sources (coal, nuclear, geothermal, solar); economic analysis of shifts among sources; industrial and market structures in the energy production sector; "Energy crisis": analysis and evaluation. The economics of long-range energy decisions: new sources and conservation and environmental protection; evaluating costs and benefits; decision model for energy technology assessment; energy-economy interactions; energy sector share of GNP; impact of energy cuts on GNP; alternative economic techniques for reducing energy consumption.

EPS 521
Urban Social Structure 3 credits
An introduction to the city as a social system. Racial and religious conflict among various segments of the urban population and its implications. Changing social stratification, urban family structure, and the concept of a "culture of poverty." The impact of social and technological change upon urban society. The physical and environmental characteristics of a city as products of social systems, as well as constraints upon behavior.

EPS 601
Research Methods 3 credits
Introduces beginning graduate students to the research tools necessary for specialized study in other environmental policy studies courses. Problem identification, research design and problem solving; methods of data analysis; gathering of original field data.

EPS 606
Technology Forecasting and Management Planning 3 credits
Prerequisite: quantitative background in science, social science, or engineering. Basic forecasting techniques such as regression analysis, scenario generating, Delphi conferencing, and morphological analysis with particular case studies and problems pertaining to the forecasting of technological development. The relation of technological forecasting to the management process and the understanding of the technological development process. Demonstration of the techniques and application to the contemporary fields of technological importance such as energy, communications, transportation, housing, and computers.

EPS 609
Environmental Risk Assessment 3 credits
Methodology to assess the social and economic risks to present-day environmental resources of air and water; cost-benefit and trade-off analysis; technical characteristics of materials such as half-life, decomposition rates, and temperature sensitivity; and probabilities of various environmental situations.

EPS 612
Introduction to Environmental Policy Studies 3 credits
Introduction to six areas essential to a comprehensive understanding of environmental policy: concept of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA, etc.); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio, etc.); industrial perspective (pollution prevention/life cycle engineering, privatization, etc.); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline, etc.).

EPS 613
Environmental History and Policy 3 credits
Explores the dialogue between humanity and the environment in the United States, as well as its global implications. Surveys fundamental themes of history and policy from an environmental perspective: colonial development, independence, western expansion, industrialization, urbanization, and the rise of a consumer society. Gives special attention to the emergence of an environmental perspective: wilderness appreciation, the conservation movement, public health, the rise of the environmental movement since the 1960s, environmental science, and the legislative and regulatory process.

EPS 614
Environmental Economics 3 credits
Detailed overview of the relationship between political economy and the environment drawing on diverse case studies including global warming, ocean resources, energy policies, and contamination of the nation's water, air and soils. Economic and social policies for the fast-changing relationship between society and nature.

EPS 615
The Politics of Science 3 credits
Geopolitical context in which scientific discovery and governmental science policy have been formulated since World War II: social construction and the constituencies that have a stake in its outcome; military influence on science policy priorities; and legislative obstacles to various science policy objectives.

EPS 616
Global Problem Solving in Science, Technology, and the Environment 3 credits
Developing policy for the coming global era. Analyses and theories on political concept of sovereign nation states; the earth as one integrated economy, technology, science, politics and ecology; multinational corporations; rise of global cities; worldwide patterns of capital and labor migration; energy flows; technology transfer; and impact of modernization and development on ecology.

EPS 621
Energy and Public Policy 3 credits
Analysis of motivation for objectives, and implementation of U.S. national energy resource policies: models and theories of policy making; analysis of types of policies; public interest vs. bureaucracy; mechanisms for innovation and obstacles to innovation within bureaucracies; and continuing strategies for citizen action.

EPS 630
Technology, Engineering and Civilization 3 credits
Technological development and technical innovation dating from the ancient world, medieval Europe, to the modern era, with emphasis on Western civilization. Comparisons of the United States, Europe, China and Japan. Major themes include the role of the military and war, proto-industrialization and industrial revolution, technology transfer, emergence of engineering as an occupational class, and the rise and decline of the United States as the world's premier technological nation.

EPS 634
Professional Ethics 3 credits
Professional ethics: its source, range, and limits. Ethical thought and behavior in Western tradition and culture as they apply to business, engineering, and government. By studying both theoretical arguments and practical, real-life case studies, students learn to recognize, analyze and evaluate the ethics of personal professional decisions about work, careers, and policies.

EPS 644
The Rhetoric of Environmental Policy 3 credits
Introduces students to the major types of rhetorical analysis as well as assures that students can analyze and write technology policy that is informed by core rhetorical principles of that analysis.

EPS 660
Ethics and Environmental Policy 3 credits
Contemporary environmental problems from the perspective of ethics or moral philosophy. Is there a moral obligation to preserve or protect the natural environment? What are the ethical presumptions and values underlying environmental policy? Are traditional theories of moral philosophy applicable to contemporary environmental problems, or is a new conception of the relationship between humanity and nature needed?

EPS 698/EPS 699
Special Topics in Environmental Policy 3 credits each
Prerequisite: advisor's approval. Topics of special or current interest.

EPS 700
Master's Project 3 credits
Prerequisite: matriculation for the master's degree and advisor's approval. Written report requiring field work, experimental, or theoretical research, or an extensive literature analysis. Work of exceptional quality may be extended to a Master's Thesis, see EPS 701.

EPS 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree, advisor's and departmental approval. Projects involving field work, experimental, or theoretical investigation carried out under the supervision of a designated member of the departmental faculty. The completed written thesis should warrant publication in a professional journal. A minimum of 3 credits per semester is required until completion.

Environmental Science

Offered by the Department of Chemical Engineering, Chemistry, and Environmental Science

EvSc 592
Graduate Work Experience 3 credits (additive) pass/fail, as needed
Prerequisite: graduate standing and permission of the graduate advisor in environmental science and the Division of Cooperative Education. Provides on-the-job reinforcement of environmental science assignments. Projects are developed by the Co-op Division in consultation with the Associate Chairperson for Environmental Science. Credit for this course may not be used to fulfill any environmental science degree requirements.

EvSc 600
Environmental Science Seminar 1 credit
Current environmental topics of interest to the environmental professional are presented. Required each semester for environmental science graduate students receiving departmental or research-based awards. Does not count as degree credit.

EvSc 602
Special Topics in Environmental Science I 3 credits
Prerequisite: approval of graduate advisor in environmental science. Topics of current interest in the environmental field.

EvSc 610
Environmental Chemical Science 3 credits
Prerequisite: one year of general chemistry. Principles of physical, inorganic and organic chemistry are applied to understanding the origins of environmental pollutants, their transport, distribution and decomposition pathways.

EvSc 611
Hazardous Waste Management 3 credits
Prerequisite: an undergraduate degree in science or engineering. An overview of hazardous waste management; case histories; legislation and regulations; treatment, disposal and cleanup technologies; sampling and analysis methodology; persistence and fate in the environment; emergency response procedures.

EvSc 612
Environmental Analysis 3 credits
The analysis of environmental samples is studied from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis, and data treatment.

EvSc 613
Environmental Problem Solving 3 credits
This course is designed to study solutions for current environmental problems. Students are asked to respond to an imaginary Request for Proposal (RFP) in writing and before a team of technical experts at an oral presentation. Solutions proposed in student RFPs must reflect knowledge of environmental science and technology in current use.

EvSc 614
Quantitative Environmental Risk Assessment 3 credits
Applications of quantitative risk assessment concepts to the management of environmental problems.

EvSc 615
Global Environmental Problems 3 credits
With an understanding that environmental problems are not restricted by geographical boundaries, relationships of the earth's temperature balance, global air circulation patterns, global energy needs, and control and remediation technologies are studied.

EvSc 616
Toxicology for Engineers and Scientists 3 credits
The general principles of toxicology are presented and applied to the assessment of acute, subacute and chronic effects of hazardous and toxic chemicals. Qualitative and quantitative measures of toxicity and testing protocols are addressed. The role of toxicology in risk assessment and risk management is discussed.

EvSc 620
Environmental Meteorology and Plume Dispersion 3 credits
Prerequisite: background in science or engineering. Elements of meteorology and the Gaussian plume dispersion model used to predict air pollution transport.

EvSc 700
Master's Project 3 credits
Prerequisite: graduate standing in the environmental science program. Written report requiring experimental or theoretical research, or an extensive literature analysis. Registration must be approved by an advisor. Students must continue to register for at least 1½ credits until at least 3 credits have been completed and a written report is accepted.

EvSc 701
Master's Thesis 6 credits
Prerequisite: matriculation for a master's degree. Approval to register for the thesis must be obtained from the advisor. Research project involving design, construction, and experimental or theoretical investigation is carried out under the supervision of a designated faculty member. The final product must be a written thesis approved by three faculty members: one from the department, the student's primary advisor, and one other faculty member. A minimum of 6 credits of Master's Thesis is required, but a student may register for 3 credits each semester until the completed thesis is approved.

EvSc 702
Special Topics in Environmental Science II 3 credits
Prerequisite: approval of graduate advisor in environmental science. Topics of current interest in the environmental field. Doctoral level course.

EvSc 711
Advanced Environmental Analysis 3 credits
Prerequisite: course in analytical chemistry or instrumental analysis. Analysis of complex environmental samples is studied, from the acquisition of representative samples, through sample handling, chain of custody, sample storage, analytical method selection, analysis and data handling. Collection and analysis of samples from air, water, soil, and biological systems will be discussed. Emphasis on the study of current literature.

EvSc 712
Air Pollution and Indoor/Outdoor Relationships 3 credits
Concepts and relationships of outdoor and indoor air pollution including the respiratory system, ingestion mechanisms, analytical methods of detection, and modeling of pollution transport.

EvSc 725
Independent Study I 3 credits
Prerequisite: written permission from the Associate Chairperson for Environmental Science plus courses prescribed by the supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which are not sufficiently broad to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

EvSc 726
Independent Study II 3 credits
See description for EvSc 725.

EvSc 727
Independent Study III 3 credits
See description for EvSc 725.

EvSc 790
Doctoral Dissertation and Research Credits as designated
Required of all students working toward the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of thesis advisor is necessary for registration. Candidates must register for at least 6 credits of dissertation per semester until 36 credits are reached, and 3 credits per semester thereafter until degree completion.

Financial Management

Offered by the School of Industrial Management

Fin 516
Principles of Financial Management 3 credits
Fundamentals of financial management divided into two segments: investment and corporation finance.

Fin 618
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as Tran 604.*

Fin 624
Financial Management 3 credits
Prerequisite: Fin 516. The management of assets, liabilities and equity in a domestic framework. Includes: goals of the firm, time value of money, financial statement analysis, financial ratio analysis, financial planning and forecasting, capital budgeting, cost of capital, capital structure, dividend policy, working capital management, mergers and acquisitions, and pricing of options.

Fin 626
Financial Investment Institutions 3 credits
Prerequisite: Fin 516. Introduces the role of banking institutions and investment banks in the domestic and international money market and capital environment to the financial managers. Covers instruments and services of financial intermediaries that are crucial to business management. Discussions range from the financial services and facilities of regional banks to money-center banking institutions. Alternatives of project financing, lending requirements and regulations, project financing, and role of intermediaries in local and international transactions. Focuses on the private placement procedures of all types of securities in the capital market and the unique role undertaken by the investment banking firms. Provides an insight about the public offering process for existing and venture capitalized firms.

Fin 627
International Finance 3 credits
Prerequisite: Fin 516. Examines financing of exports and imports, managing multicurrency working capital, international aspects of capital budgeting, cost of capital and their relationship with political, economic, and financial risk. Explores financial innovations and their impact on the firm's financial strategy and performance of overall productivity. Discusses the tax consequences and principal-subsidiary relationship of the multinational enterprise. Introduces international money and capital markets, instruments, derivatives, and institutions.

Fin 630
Applied Business Econometrics 3 credits
Prerequisite: undergraduate course in economics. Econometric models are equations that describe relationships among economic variables. Stochastic properties of the variables require the application of statistical techniques. Combining modeling concepts with statistical techniques offers a basis for decision making and predictions in management, economics, and related fields.

Fin 631
Working Capital Management and Credit Analysis 3 credits
Prerequisite: Fin 516. Optimal management of a firm's working capital, such as cash, marketable securities, receivables, and inventories with an emphasis on the institutional background and environmental modeling. Deals with cash flow analysis, the assessment of financial needs, and selecting the appropriate domestic and international sources for meeting a firm's credit needs.

Fin 632
Financial Valuation of Technology-Based Companies 3 credits
Prerequisite: Fin 516. Concentrates on techniques and procedures of assessing, managing, and forecasting value of alternative corporate and business level strategies of companies with emphasis on technology-based companies. These strategies include new product introduction, joint venture agreements, new market entries, and capital expenditures. Assess the extent of current performing and configured creating values.

Fin 634
Mergers, Acquisitions, and Restructuring 3 credits
Prerequisite: Fin 516. Focuses on identifying and evaluating potential and international companies for mergers and acquisitions as well as structuring of deals. The financial,

social and managerial implications of these changes in corporate ownership will be examined. Topics are: financing M&A's, deal structuring, tax implications, valuation, broker/finder agreements, merger negotiations, and post-merger integration.

Fin 660
Financial Planning and Decision Making
3 credits
Prerequisite: Fin 624. This course introduces the in-depth qualitative and quantitative analysis of the short-term and long-term investment and financing decisions in an uncertain environment. The course emphasizes a quantitative analysis (simulation model) and case studies that deal with actual business decisions and challenges. Students are assigned to competing financial management teams in order to develop financial planning and decision making expertise.

Fin 700
Seminar in Theory and Research in Financial Management 3 credits
Prerequisites: Fin 624 or Fin 626; waived with approval of the Dean. Only open to those students who do not do a thesis. The theory and applied tools of financial management. Presented in seminar format with several students working as a team to analyze and resolve an issue in financial management.

Fin 701
Methods of Research in Financial Management 3 credits
Prerequisites: Fin 624 or Fin 626; waived with approval of the Dean. Examines what is research? Why do research? What are the objectives of research? Covers the need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

Geology

Offered by the Department of Geology at Rutgers-Newark

26:460:577
Seminar in Environmental Geology
3 credits
Human interaction with the geological environment. Case histories involving geological hazards to engineering works, transportation, land use, water, mineral and energy resources, disposal of wastes, and public health.

History

Offered by the Federated Rutgers-Newark/ NJIT History Department. Courses in the history of technology, environment and medicine are listed below and are taught at NJIT. Courses in American history and global history are listed under Rutgers-Newark History Courses and are taught at Rutgers-Newark.

Hist 622
Culture and Science in the History of American Medicine 3 credits
Provides an overview of American medical history and a familiarity with the theoretical and practical ramifications of different approaches to the complex relationships between medicine, science, and culture. Topics include: the extent to which medicine is or has been scientific; reasons why science has been considered so important to medicine's professional culture; and the degree to which medicine's professional culture has been shaped by science as well as other factors, such as economic and political self-interest, technology, class, race, gender, and other kinds of cultural values.

Hist 624
Technology, Environment and Medicine in World History, 1500-1900 3 credits
Examines the interrelationship between the emerging modern world system and changes in technology, environment, and medicine, with particular emphasis on European overseas expansion and its impact in non-Western regions.

Hist 626
Social History of American Medicine Since 1800 3 credits
Topics include the practices of 19th-century "regular" medicine; the relation between medical concepts and mainstream social thought; the treatment of women's health; antebellum alternative healers and alternative politics; the triumphs of late 19th- and early 20th-century medical therapeutics; the emergence of medicine as big business; medicine and racism; the emergence of nursing as a profession; modern medicine in international perspective; New Age healing; the AIDS crisis and AIDS activism; and contemporary debates on the future of health care in the United States.

Hist 628
Gender, Science and Technology in the Modern World 3 credits
Introduction to a wide range of political and cultural analyses of science and technology, with an emphasis on recent feminist critiques of science. Explores the questions of scientific neutrality; the gendering of scientific knowledge; the relationship between science, technology, and capitalism; the role of science in international politics; and why science has not freed women.

Hist 630
History of the Body in Modern Western Culture 3 credits
Considers medical or scientific history primarily in terms of implications for bodily experience in everyday life. Begins with grand narratives of historical shifts in bodily perceptions and practices, and proceeds to more focused narratives of changing bodily experience, engaging key distinctions between genders, classes, and species as well as perceptions of pain and internal bodily structure. Materials will be drawn from early modern and modern Europe, as well as more recent bodily experience in the United States.

Hist 632
Technology, Culture and History 3 credits
Treats the relationship between technology and cultural values in a variety of historical and geographical settings, from early modern Japan to twentieth-century America. Examines the ways in which cultural ideals, conceptions, and preconceptions serve to influence the rate and manner of technological change, as well as the ways in which technology affects social and cultural life.

Hist 634
Environmental History of North America
3 credits
Explores the dialogue between humankind and the environment in North America over the course of the last four centuries. Examines the latest and most interesting work done in the new field of environmental history to see what such a perspective has to offer.

Hist 636
Environmental History: Theory and Method
3 credits
Surveys the literature and methods of the new field of environmental history, an interdisciplinary field of study. Understanding the value and importance of interdisciplinary scholarship, awareness of the different disciplines that are critical to the practice of environmental history.

Hist 644
War, Technology and Society, 1500-1914
3 credits
Examines key themes in the interrelationship between warfare, technology and society from the beginnings of modern warfare until World War I. Primary emphasis placed on the historical connections between violent conflict, the technical means by which it is carried out, and the socio-political environment within which wars take place. The effect of technology upon war and considerations of the effect of war on technological change and development. Samples the rich tradition of thought and ideas produced by philosophers and theorists on these themes.

Hist 701
Master's Thesis 6 credits
Prerequisite: permission of graduate history advisor. For students writing a master's thesis in the history of technology, environment and medicine.

Hist 725, Hist 726, Hist 727
Independent Study in History 3 credits
Prerequisites: permission of graduate history advisor and course instructor.

Hist 791
Seminar in History of Technology, Environment and Medicine Non-credit
Faculty, students and invited speakers present and discuss current topics of research in history, technology and medicine.

Rutgers-Newark History Courses

26:510:520
Topics in the History of Technology
3 credits
Selected topics in the history of technology.

26:510:525
Colloquium in the History of Women
3 credits
Readings and discussion on the history of women in the United States and Western Europe.

26:510:526
Problems and Readings in Afro-American History 3 credits
An introduction to the major historiographical problems and recent literature in the history of Afro-Americans in the U.S.

26:510:527,528
Selected Topics in European Political and Diplomatic History 3 credits each
An examination of issues and methods in European political and diplomatic history, with a consideration of some leading problems in the field.

26:510:529,530
Selected Topics in European Intellectual and Cultural History 3 credits each
An examination of issues and methods in European intellectual and cultural history, with a consideration of some leading problems in the field.

26:510:531,532
Problems and Directed Readings in the History of U.S. Foreign Policy and Diplomacy 3 credits each
An examination of issues and methods in American diplomatic history, with a consideration of some leading problems in the field.

26:510:533,534
Selected Topics in American Social and Economic History 3 credits each
An examination of issues and methods in American social and economic history, with a consideration of some leading problems in the field.

26:510:537,538
Problems and Readings in the Ancient World 3 credits each
An introduction to the major historiographical problems and recent literature of the ancient world.

26:510:539,540
Problems and Readings in Medieval History 3 credits each
An introduction to the major historiographical problems and recent literature in medieval European history.

26:510:541,542
Problems and Readings in European History 1350-1650 3 credits each
An introduction to the major historiographical problems and recent literature in European history from 1350 to 1650.

26:510:543,544
Problems and Readings in European History 1650-1850 3 credits each
An introduction to the major historiographical problems and recent literature in European history from 1650 to 1850.

26:510:545,546
Problems and Readings in European History Since 1850 3 credits each
An introduction to the major historiographical problems and recent literature in European history since 1850.

26:510:547
Comparative World Colonialism 3 credits
Examines interactions of Europeans and non-Europeans after 1500. Emphasis is on comparative analysis of the colonial experience in Asia, Africa, and Latin America.

26:510:548
Topics in the History of the American Environment 3 credits
Selected topics in the history of the interaction between humans and the environment in North America.

26:510:551,552
Selected Topics in American Intellectual and Cultural History 3 credits each
An examination of issues and methods in American intellectual and cultural history, with a consideration of some leading problems in the field.

26:510:553,554
Selected Topics in American Political and Legal History 3 credits each
An examination of issues and methods in American political and legal history, with a consideration of some leading problems in the field.

26:510:555,556
Selected Topics in American Urban and Ethnic History 3 credits each
An examination of issues and methods in American urban and ethnic history, with a consideration of some leading problems in the field.

26:510:557,558
Selected Topics in European Social and Economic History 3 credits each
An examination of issues and methods in European social and economic history, with a consideration of some leading problems in the field.

26:510:559
Cities in Change I 3 credits
The process of urbanization as seen in the growth of historic European and North American cities and in the underdeveloped world: the revival of towns in the Middle Ages, the royal capital as center of power, rise of an urban way of life, nineteenth-century industrial cities, changing city forms and functions of the twentieth century, urban values in politics, business, and material culture.

26:510:560
Cities in Change II 3 credits
The process of urbanization as seen in the growth, decline, and revival efforts of Newark, N.J. Examination of the economic, political, geographical, and social factors that helped develop Newark as New Jersey's most important city and as one of the most troubled urban communities in the U.S. Attention to the origins of Newark's decline; its relationship with suburban communities in northern New Jersey; the settlement of European immigrants and rural Afro-Americans in the late nineteenth and twentieth centuries; and recent efforts to revive the city's political, economic, and cultural life.

26:510:566
American Historiography 3 credits
Examines the major historiographical disputes among American historians, including such topics as Jacksonian Democracy, the Civil War, foreign policy, the Progressive Era, and the New Deal.

26:510:567,568
Modern Russia 3 credits each
Major themes of post-Petrine Imperial Russia and the Soviet Union.

26:510:569
American Legal History to 1860 3 credits
Readings and discussion of the legacy of common law after the Revolution, the emergence of legal instrumentalism, and the evolution of tort, contract, and damages in the context of industrialism and economic growth.

26:510:570
Topics in American Legal History 3 credits
Readings and discussion of the growth of legal formalism, the evolution of substantive due process, changes in legal education and the legal profession, and the evolution of private law.

26:510:571
Introduction to Historical Method 3 credits
Examines major theoretical approaches that have been used by historians and some of the works that have employed those approaches.

26:510:572
Philosophy of History 3 credits
A general survey of major trends in historiography and of leading issues in the philosophy of history.

26:510:573,574
Problems in Central European History 3 credits each
Topics in the nineteenth- and twentieth-century political, social, and intellectual history of Germany. The Hapsburg monarchy and its successor states.

26:510:576
Problems and Readings in American History, 1492-1789 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1492 to 1789.

26:510:577
Problems and Readings in American History, 1789-1865 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1789 to 1865.

26:510:581
Problems and Readings in American History, 1865-1912 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1865 to 1912.

26:510:583
Problems and Readings in American History, 1912-1945 3 credits
An introduction to the major historiographical problems and recent literature in American history from 1912 to 1945.

26:510:585
Problems and Readings in American History, 1945 to Present 3 credits
An introduction to the major historiographical problems and recent literature in American history since 1945.

26:510:589,590
Problems and Readings in African History 3 credits each
Various problems in African history, from the ancient African civilizations to the present day. Topics vary from year to year; contact the instructor for current topics.

26:510:618
Seminar: Teaching of History 3 credits
Experience in the planning of a course, leading discussions, and lecturing under the supervision of the student's major professor. Critiques are made by both the professor and the seminar participants.

26:510:669
Business and Government in the Twentieth Century I 3 credits
An exploration through selected readings of industrial and financial concentration in the U.S. and attempts at resolution of the dilemma through overhead management (the New Deal), associationalism (the trade association), and decentralism (antitrust).

26:510:670
Business and Government in the Twentieth Century II 3 credits
Examines the history of the relationship of federal government policies, presumptions, and practices to American business activity—financial, industrial, and commercial—outside the U.S.

26:510:695
Individual Studies in History 3 credits
Prerequisite: permission of the director of graduate programs. Offered both terms.

26:510:696
Advanced Individual Studies in History 3 credits
Prerequisite: permission of the director of graduate programs. Offered both terms.

26:510:697,698
Research in History 3 credits each
Normally reserved for master of arts thesis credit.

Human Resource Management

Offered by the School of Industrial Management

HRM 601
Organizational Behavior 3 credits
Analysis of key organizational components; individual perception; learning ability; conflict resolution models; group processes in decision making; motivation; problem diagnosis, and the organization as the mechanism for joining into a coherent productive system. Organizational assessment for innovation, leadership styles, and environmental interaction.

HRM 606
Human Resource Management 3 credits
Management of human resources in business, industry, and government; developing personnel programs including wage and job classification, training, employee and labor relations, and accident prevention. Particular attention is directed to cases and roles involving both line and staff managers.

HRM 607
Personnel and Evaluation Research 3 credits
Focuses on the assessment and improvement of personnel systems. Emphasis is on the use of diagnostic tools in problem identification, developing action plans, and assessing outcomes of HRM interventions. Special attention is given to survey methodology and to the use of assessment tools in conducting personnel research. Databases and statistical software packages are used in project work.

HRM 608
Behavioral Issues in Transportation Studies 3 credits
Behavioral science concepts and principles such as perception, learning, motivation, and information processing as they relate to: transportation, consumer use of mass transit, automobiles, ridesharing and intelligent transportation systems. *Same as Tran 608.*

HRM 609
Employee Development and Training 3 credits
Key concepts in training including needs analysis, curriculum design and delivery, managing external consultants, and the evaluation of off-site training programs are introduced to gain understanding of the training function in organizations. Emphasis is on the impact of technological changes on employee skills utilization and development; training as a means of sustained competitive advantage for technology-based organizations; and the effects of technological advances on the design and delivery of training programs.

HRM 616
Job Analysis and Design 3 credits
Analyzing and designing jobs in work organizations, particularly technology-based organizations. Principles of job analysis and job design are applied to the allocation of tasks in organizations. Draws upon theory and research from industrial and organizational psychology, organizational sociology, social psychology, industrial engineering and occupational medicine.

HRM 630
Managing Technological and Organizational Change 3 credits
Prerequisite: HRM 601. Managing planned and unplanned change in organizations. The change process is studied in relation to technology-driven changes in the workplace and to other environmental factors (e.g. Workforce 2000). Focuses on planned and unplanned systemic change, such as downsizing, re-engineering, mergers, and acquisitions.

HRM 640
Seminar on Cultures in Organizations 3 credits
Prerequisite: HRM 601. Cultures and subcultures in organizations are studied from an ethnographic perspective. Managerial and professional cultures are studied as are engineering and R&D cultures. Organizational cultures are also studied in detail using case studies, with an emphasis on understanding culture as a control mechanism in modern organizations.

HRM 650
Human Resource Information Systems 3 credits
Information systems as a tool in improving human resource functions in organizations. Emphasis is on the design of information systems and their applications to HRM problems. The course is applications oriented and does not have a large technical component relating to the management of information systems.

HRM 660
HRM Issues in Technology-Based Organizations 3 credits
Prerequisite: HRM 606. An interactive course that emphasizes the special problems faced by organizations that include a high percentage of technically trained professional employees. Linkages between HRM functions are examined and then built upon to develop a strategic plan for the firm's human resources. Special attention is directed toward the needs of technology-based organizations such as building technical skills aimed at maintaining competitive advantage; managing innovation; assessing employee skills bases company-wide; cross training; and fostering organizational learning. Case studies and comparative analyses are used extensively.

HRM 662
Organizational Diagnosis and Development 3 credits
A problem-oriented approach to organizational development with a focus on improving work group and organizational performance. Diagnostic tools are introduced as a means of problem definition. Attention then turns to structural and process issues in organizational development. Fit issues with respect to technology and structure are also examined. Emphasis is primarily on the internal organization. Representative topic areas include self-managed work teams, empowerment strategies, work group structures and technologies, and conflict resolution strategies. Development also covers quality of work life issues.

HRM 670
Advanced Issues in Resource Management 3 credits
Prerequisite: permission of the instructor. A research-based course that studies current issues in HRM. Course is designed for Ph.D. students.

HRM 685
Cross Cultural Management Studies
3 credits
Provides insight into the institutional fabric and social and communication behavior of other cultures to better understand problems arising from cultural aspects of managing and doing business in various countries. Focus will be with the manager acting in various cultural environments, not restricted to the traditional human resource function at corporate headquarters. Cultural differences and technologies are also examined.

HRM 693
Employment Relationships and the Law
3 credits
Legal issues in government regulation of labor-management relations: selection and designation of bargaining agents; administration and enforcement of collective bargaining agreements; activities of unions and employers in labor disputes; and laws regulating wages, hours, and benefits.

HRM 700
Theory and Research in Human Resource Management 3 credits
Prerequisites: matriculation and advisor's approval. Comprehensive proposal for a program of human resource management; or a major component of a management program applied to an organization chosen by the student, including a design for recruitment, selection, OSHA, benefits services, and/or training program with an evaluation procedure. Another alternative is a comprehensive evaluation of existing human resource programs, including human resource plans and personnel operations requiring cost-benefit analysis. Students select an acceptable organization on which to base their proposal plans.

HRM 701
Methods of Research in Human Resource Management (Master's Thesis) 6 credits
Prerequisites: matriculation for the master's degree, adequate graduate courses in the field of proposed research, and research advisor's approval. Thesis may be developmental experience at an appropriate professional level, or a scholarly research paper providing useful data and/or conclusions for other professionals interested in further study. A student must register for a minimum of 3 credits per semester. Credit will be limited, however, to the 6 credits indicated.

Industrial Engineering

Offered by the Department of Industrial and Manufacturing Engineering

IE 501
Fundamentals of Industrial Engineering 3 credits
Basic concepts of industrial engineering for students who lack an undergraduate degree in the discipline, including: manufacturing processes, work methods and measurement concepts, basics of human factors, quality control, facilities design, production planning, operations research tools, and simulation models.

IE 590
BS/MS Co-op Work Experience I
3 credits (additive)
Prerequisites: standing and acceptance in the combined BS/MS program and permission from the industrial engineering program director and the co-op office. Cooperative education internship providing on-the-job reinforcement of academic programs in industrial engineering. Work assignments and projects are developed by the co-op office in consultation with the industrial engineering program director. Work assignments are related to student's major and are evaluated by faculty coordinators in the IE department. Course cannot be applied toward degree credit.

IE 591
BS/MS Co-op Work Experience II
3 credits (additive)
Prerequisite: IE 590 and permission from the industrial engineering program director, and the co-op office. Continuation of IE 590. Course cannot be applied toward degree credit.

IE 592
Co-op Work Experience III 3 credits (additive)
Prerequisites: IE 591, graduate standing and permission from the industrial engineering program director, and the co-op office. Continuation of IE 591. Course cannot be applied toward degree credit.

IE 601
Measurement Methods for Performance Analysis of Operations 3 credits
Prerequisite: undergraduate mathematics for management science, or EM 602. Quantitative study of various analytical methods for designing and evaluating systems employed in the management of complex enterprises such as decision-making, efficiency measurement, and methods for obtaining optimal system performance.

IE 603
Behavioral Science in Engineering Organization 3 credits
Prerequisite: undergraduate probability and statistics, or EM 503. A study of scientific research on human behavior in organizations. Processes and problems of communication in engineering activities; line-staff and supervisor-subordinate relationships; formal and informal organizations; organization models; and technical and social structure of organizations.

IE 604
Advanced Engineering Statistics
3 credits
Prerequisite: IE 331 (see undergraduate catalog for description) or equivalent. The foundations of modern quality improvement, scientific basis of quality engineering, probability, statistical inference, statistical experimental design issues such as randomized blocks, factorial design at different levels, application to factorial design, building models, and implementation and critique of Taguchi's contributions. Statistical software is used in the data analysis.

IE 605
Engineering Reliability 3 credits
Prerequisite: statistics. Concepts of modern reliability applied to practical industrial problems: statistical concepts, reliability through design, reliability through testing, analysis of reliability data, and the organization and management of a reliability program. Offered alternate years.

IE 606
Maintainability Engineering 3 credits
Prerequisite: statistics. Factors affecting maintainability design applied to military and industrial problems: statistical concepts; maintainability prediction, allocation, and demonstration; availability, system and cost-effectiveness; provisioning; optimal maintenance policies; and management of a maintainability program.

IE 608
Product Liability Control 3 credits
Product liability and the effect of legal doctrines on minimizing hazards of design and manufacture. Use of actuarial techniques and legal precedents applicable to design, manufacturing, advertising, and marketing problems: warranties, notices, disclaimers, definition of liability, use of expert witnesses, reliability prediction and analysis methods, safety engineering concepts, and design review. A review of government regulations for safety and protection, as well as mandatory and voluntary standards will also be included.

IE 609
Advanced Analytical Engineering Statistics 3 credits
Prerequisite: IE 604. An extension of the techniques of engineering statistical analysis to industrial applications. Emphasis is placed on the design of experiments and analysis of tests for multivariate level problems.

IE 610
Transportion Economics 3 credits
Prerequisite: undergraduate course in economics. Principles of engineering economy. Costs of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. *Same as Tran 610.*

IE 612
Robotic Manufacturing Systems 3 credits
Industrial robotic programming and control. Robotic end effectors and sensors, tactile and vision. Cell design and control. Artificial intelligence. Robotic project using one of twenty industrial robots. Economic analysis and productivity. Material transfer, machine loading, assembly, inspection, welding, painting, and safety aspects. Hardware/software interfacing.

IE 613
Manufacturing Engineering 3 credits
Prerequisites: undergraduate production process design and engineering cost analysis. Description of the manufacturing process and its associated elements. Analysis of production systems, equipment selection and justification, and process control methods. Introduction to CAD, CAM, robotics and other automation technologies in the manufacturing area.

IE 614
Safety Engineering Methods 3 credits
Prerequisites: introductory course in statistics and industrial or construction management. Application of selected safety engineering methods to detect, correct, and prevent unsafe conditions and procedures in future practice. Methods selected are from safety management and programs; loss prevention; fire protection; systems safety; the design of buildings and other facilities; and the design of products, machinery, and equipment. Engineering problems in designing and constructing a hazard-free environment.

IE 615
Industrial Hygiene and Occupational Health 3 credits
Prerequisites: one year of college physics and one semester of college chemistry or biology. Introduction to industrial hygiene. Recognition, evaluation and control of human exposure to noise, heat, bio-hazards, chemicals, radiation, and improper lighting. Government standards, field measurements, work practices, engineering designs, and the effects of excessive exposure on worker health and productivity.

IE 616
Planning and Control of Products and Processes 3 credits
Prerequisites: EM 602 or knowledge of operations research, and probability and statistics. A study of the principles and procedures used by job order, continuous and batch types of industries in forecasting, planning, and controlling production goods. Emphasis is placed on the organization of the control group and the development of control criteria. Topics are sales forecasting; product and process analysis including procurement, inventory control; tool management; routing; scheduling; dispatching; and control mechanisms of manufacturing and service systems.

IE 618
Engineering Cost and Production Economics 3 credits
Prerequisite: IE 502 or equivalent. Cost management of operational activities. Focuses on capital investment decision making and efficient resource utilization to achieve cost-effective operations. Topics include alternative investment evaluation, budgeting activity based costing, quality costs, life cycle management and relevant behavioral science. These are considered in the context of manufacturing and service industry application.

IE 621
Application of Digital Computers in Industrial Engineering 3 credits
Prerequisites: IE 331, IE 466 or equivalent or department approval. The application of well-integrated systems approach, systems and systems engineering in the system life cycle, system design process, mathematical tools and techniques applied to systems analysis, design for operational feasibility, systems engineering management, modeling techniques including simulation, application of discrete simulation techniques to model industrial systems, design of simulation experiments using software, output data analysis.

IE 623
Linear Programming 3 credits
Prerequisite: EM 602 or introductory course in operations research. Principles, methodology, and practical applications of linear programming to complex problems in production and marketing, simplex techniques, duality theory, parametric analysis, Wolfe and Dantzig's decomposition methods, ellipsoid method, and Karmakar's method.

IE 624
Heuristic Methods 3 credits
Prerequisites: EM 503 or equivalent. Techniques and concepts used to develop "intelligent" decision support systems. Application of rules called heuristics and models of reasoning to solve problems in engineering design and manufacturing. Topics include set theory, fuzzy subset theory, decision theory, logic, inference expert systems and single and multi-fault diagnostics.

IE 641
Operations Analysis 3 credits
Prerequisites: EM 602 and computer programming experience. Management systems and business behavior using industrial models. Special attention is given to the interaction of individual elements that make up the total system.

IE 642
Network Flows and Applications 3 credits
Prerequisite: EM 602 or equivalent. Theories, algorithms, computation complexity, and application of networks, shortest path, network flow, and minimum cost flow problems. Models of industrial service systems as network problems.

IE 643
Transportation Finance 3 credits
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. *Same as Tran 643.*

IE 644
Application of Stochastic Modeling in Systems Control 3 credits
Stochastic processes applied to control of various types of systems: Markov chains, queueing theory, storage theory applications to measure performance of flexible manufacturing systems, telecommunication and distributions networks and similar service systems. Knowledge of probability theory and linear algebra is essential.

IE 650
Advanced Topics in Operations Research 3 credits
Prerequisite: introductory course in operations research or equivalent. Current topics in deterministic models of operations research: linear programming, large scale decomposition, integer programming, dynamic programming, and nonlinear programming. Emphasis on optimization techniques for solving mathematical programming problems.

IE 651
Industrial Simulation 3 credits
Prerequisite: Introductory course in statistics/simulation or instructor's permission. Statistical design and analysis of Monte Carlo simulation experiments from an engineering view. Examples are provided with emphasis on industrial and manufacturing applications of simulation modeling. Markovian processes simulation, random number generation, mathematical programming, heuristics and decision theory.

IE 652
Facilities Location and Plant Layout 3 credits
Prerequisite: introductory course in operations research or instructor's approval. Basic concepts of facilities location and plant layout. Quantitative and qualitative tools needed in industrial engineering, including single and multiple facilities location problems, site selections and allocation models, use of Duality theory in location and plant layout problem, and computerized layout planning.

IE 653
Facility Maintenance 3 credits
Prerequisite: EM 501 or equivalent. Intended for those individuals who manage the functioning and maintenance of physical facilities. Emphasis on planning and control of facilities use, maintenance, utility management, managerial control, budgets and costs, personnel administration, legal and safety.

IE 654
Design for Manufacturability 3 credits
Prerequisites: IE 613, MnE 601, or instructor's approval. Methodologies used in the synthesis and analysis of product design to optimize manufacturability. The relationship of design to production processes, product material, material handling, quality costs, and CAD/CAM are presented. Emphasis is on both formed products and assembled products. Simulation and other design analysis tools are employed.

IE 655
Concurrent Engineering 3 credits
Concurrent/simultaneous engineering methods and tools such as system analysis, system modelling and system integration, market oriented, integrated design for manufacturing, assembly, quality and maintenance, product design analysis, integrated product design and manufacturing innovation methods, QFD (Quality Function Deployment)—applied to concurrent engineering, FMEA (Failure Mode and Effect Analysis), POKA-YOKE, KANZEI, waste reduction, quality circles, rapid prototyping of designed objects and various other advanced processing methods.

IE 656
Flexible and Computer Integrated Manufacturing 3 credits
Prerequisites: EM 602, and IE 613 or MnE 601, or instructor's approval. Integrated manufacturing as a decision and information network, with appropriate automation; manufacturing LANs, MAP, PDES, programmable controllers, and MRP-II are discussed in technical detail; group technology, cellular manufacturing and relevant process planning approaches; mathematical techniques for CIM and FMS scheduling and control; flexibility measurement, and design.

IE 661
Man-Machine Systems 3 credits
Prerequisite: human factors engineering. Analysis of integrated man-machine systems: physical and psychological effects of systems of deterministic and conditional responses of individuals and groups, and the resulting interaction between individuals, groups, and machine systems; also current research and development pertaining to man-machine systems.

IE 669
Human Design Factors in Engineering 3 credits
Prerequisite: engineering statistics. Human factors research related to workplace and equipment design and development. Capabilities and limitations of the human sensory-motor system. Design of displays and resulting interaction between individuals, groups, environments and machine systems. Current research in the engineering fields pertaining to the man-machine interface. Not for IE students who have had an undergraduate course in human factors.

IE 670
Industrial Work Physiology 3 credits
Prerequisite: IE 669 or equivalent. A study of human physiological responses to industrial environmental factors emphasizing knowledge of human anatomy and physiological tolerances: skeletal, muscle, and neuromuscular systems, evaluation of physical work capacity and performance, changes in circulation and respiration during work. Semester project under the instructor's supervision is also required.

IE 672
Industrial Quality Control 3 credits
Prerequisite: engineering statistics. The management of quality assurance: operational and statistical principles of acceptance sampling and process control; quality problems in production lines, and introduction to total quality management concepts.

IE 673
Total Quality Management 3 credits
Introduces the concept of total quality management as applicable to industrial systems. Presents methods for product quality improvement. Emphasis is on prevention through quality engineering and design, and goes beyond traditional statistical process quality control. Presentation of recent methods in supplier management, quality assurance, process control, and competitor analysis. Includes Taguchi methods and quality function deployment. Description of ISO 9000 and Baldridge Award.

IE 675
Safety in Facility and Product Design 3 credits
Prerequisite: IE 614 or equivalent. Application of safety principles to minimize the health and safety hazards in the design and manufacture of various products. Practical techniques for, and economic ramifications of, conformance with the many statutes enacted to assure safe workplaces and products.

IE 677
Applied Statistics and Epidemiology for Hazard Analysis 3 credits
Prerequisite: IE 604 or equivalent. Application of statistical concepts to the field of hazard analysis including: investigation of root causes of accidents, their patterns and trends; rules for systematic data analysis; determination of commonality factors; availability and use of customized computer software.

IE 685
Systems Safety
Prerequisites: applied probability/statistics and introductory safety. Safety decision making and systems engineering applications to safety, including planning, managing and conducting system safety programs.

IE 699
Special Topics in Industrial Engineering 3 credits
Prerequisite: approval from the Industrial Engineering Division. Special course given when interest in a subject area develops. Advanced notice of topics will be given before registration.

IE 701
Master's Thesis 6 credits
Prerequisites: matriculation for the master of science, thesis advisor's approval, and adequate graduate courses in the field of the proposed thesis. Candidates for the degree who choose this option must submit an acceptable thesis on an approved subject that

contributes to the literature of the field, and preferably aids the candidate in his or her present, or a potential, career. While original research may not always result, the thesis should provide a new conclusion or application. Approval to register for the thesis must be obtained from the thesis advisor. A student must continuously register for a minimum of 3 credits per semester until the thesis is completed. Total credit will be limited, however, to the 6 credits indicated for the thesis.

IE 704
Sequencing and Scheduling 3 credits
Prerequisite: IE 650 or equivalent. Advanced sequencing and scheduling for job shops, flow lines, and other general manufacturing and production systems are discussed in this course. Both deterministic and stochastic scheduling models are covered in detail. Heuristics and worst case analysis for "unsolvable" hard scheduling problems (NP-C problem) are introduced.

IE 705
Mathematical Programming in Management Science 3 credits
Prerequisites: IE 623 and IE 650. An advanced study of various mathematical programming techniques such as linear and non-linear, parametric, integer, stochastic and dynamic programming. Readings and discussions emphasize the mathematical advances and applications in operations research. Offered alternate years.

IE 706
A Queueing Approach to Performance Analysis 3 credits
Prerequisite: IE 644 or equivalent. Newly developed techniques in the area of queueing networks that play a critical role in studying several aspects of discrete event stochastic systems such as FMS, computer-aided communication systems, transportation systems and service systems.

IE 725
Independent Research 3 credits
Prerequisite: approval from the Industrial Engineering Division. Program of study prescribed and approved by student's advisor. This special course covers areas in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course.

IE 743
Transportation Performance and Productivity 3 credits
Prerequisite: EM 640. Concepts of financial efficiency and resource productivity with applications in freight movement, storage and airline operations. The special goals of public transportation, e.g., cleaner environment and mobility of the disadvantaged. Definitions and development of performance indicators for operating efficiency, effectiveness, quality of service and societal impacts. Comparative analysis of the nation's transit systems.

IE 753
Airport Design and Planning 3 credits
Prerequisite or corequisite: Tran 610 or EM 693. Planning of individual airports and statewide airport systems. Functional decision of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. *Same as CE 753 and Tran 753.*

IE 754
Port Design and Planning 3 credits
Prerequisite: Tran 610 or EM 693. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as CE 754 and Tran 754.*

IE 760
Quantitative Methods in Human Factors 3 credits
Prerequisite: IE 661. More advanced human factors engineering concepts analyzed quantitatively: systems modeling, control theory, human error, and decision making. Discussion of human factors, research design and data analysis. Operator/computer interaction is also emphasized.

IE 761
Advanced Studies in Human Factors 3 credits
Prerequisite: one year of graduate work in human factors or the equivalent. The course integrates various areas of graduate studies in human factors such as: work physiology, occupational safety, environments (e.g., noise, thermal comfort, etc.), human-machine systems, etc. Detailed discussion of selected current papers covering theoretical review, experimental design, results, applications, and future research. Completion of semester project under instructor's guidance is mandatory.

IE 762
Psychophysical Methods in Human Factors 3 credits
Prerequisite: one year of graduate work in human factors or instructor's approval. This course considers various classical and modern psychophysical methods, signal detection theory, information theory, and human information processing applicable to advanced human factors/occupational safety research measurement and normative modeling.

IE 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Discussion of research procedures, thesis organization, and content. Students engaged in research will present their own research for discussion and criticism.

Information Systems Management

Offered by the School of Industrial Management

MIS 545
Management Information Systems
3 credits
Tools and techniques of management information systems and how they can be used to improve the quality of management decisions. Includes computer-based solutions to management problems in office automation, budgeting, communications, and decision support, major features of hardware and software computer system components and how to design a system, and technical tools ranging from flowcharts and decision tables to automated design.

MIS 620
Computing Concepts for Managers
3 credits
The manipulation of relational databases. Normally the main language will be SQL, which facilitates the use of personal computer-based database management software.

MIS 630
Accounting and Auditing Software
3 credits
Using commercially available PC software and a business database, students will select and evaluate audit data. Work will culminate in an audit report.

MIS 635
Management of Telecommunications
3 credits
A comprehensive review of current trends in telecommunicationsd with an emphasis on the techniques required by non-technically trained managers to deal with hardware, software, and human interfaces. Specific areas to be covered include the types of telecommunication networks, common network operating systems, and network design strategies.

*MIS 636
Telecommunications: Policies and Regulations
Familiarization with government regulations for all forms of telecommunications, including video and audio. Covers such aspects as the ways in which corporations manage and provide security for telecommunications. Covers briefly: major telecommunications policies and regulations that have made a major impact on the current environment; telecommunications regulations in a global environment.

*pending

MIS 640
Auditing Business Information Systems Being Developed 3 credits
Focuses on audit participation in the various phases of the development life cycle. The benefits of audit involvement in each phase will be described.

MIS 645
Operations Management, Planning and Control 3 credits
Prerequisite: MIS 545. The management of information processing resources, including: role of information processing, estimates of personnel resources and budgets, integration of corporate and MIS plans, organizational alternatives for MIS departments and support staffs, management of computer operations, equipment and general software acquisitions, intermediate and long-range MIS plans, integration of personal computers, minicomputers, and mainframes, and security and controls.

MIS 648
Decision Support Systems 3 credits
Prerequisites: MIS 545, Mgmt 580. Covers the use of decision support systems to support management decision making in a real world environment. Topics include: establishing and measuring decision support systems success criteria, software tools, model management, elements of artificial intelligence, and statistics. Justification, design, and use of decision support systems.

MIS 654
Design of Accounting Information Systems 3 credits
Management's need for information and design of systems to provide this information. Emphasis on designing controls to ensure that the system meets management's objectives. Comparison of management and technical aspects of information systems. Accounting information systems will be used as models, but the course will incorporate all functions within the organization and provide the student with tools needed to manage the system and safeguard the assets of the organization.

MIS 650
Advanced Operational and Information Systems Audit 3 credits
Covers contemporary issues in internal auditing.

MIS 655
Informational Systems Audit, Control and Security 3 credits
Emphasizes controls and how an auditor or a manager verifies that controls are in existence and are effective. Security and controls are complementary and should be included in an MIS system environment. Covers the internal controls that should be present in an information system given its environment.

MIS 680
PC Tools for Managers 3 credits
Presents a cross section of the personal computer tools available to most managers. Includes traditional spread sheets, word processors, and databases as well as presentation graphics, project management, and others.

MIS 690
Executive Information Systems 3 credits
Provides decision makers a framework for designing and building systems to gain competitive advantage. Covers executive support systems, executive information systems, and group support systems.

MIS 701
Methods of Research in Information Systems Management 3 credits
Prerequisites: MIS 645, MIS 648, CIS 675, CIS 679 or waived with approval of the Dean. Examines what is research? Why do research? What are the objectives of research? Covers need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

Infrastructure Planning

Offered by the School of Architecture

MIP 601
Interdisciplinary Infrastructure Studio I 6 credits
Collaborative work on realistic infrastructure projects by teams of students with different professional backgrounds under the supervision of interdisciplinary faculty. A project manager coordinates and ensures that working conditions in practice are simulated in the studio. Projects include analytical, financial and design components and emphasize planning strategies and the coordinating function of the design process. Studio products are presented orally in reviews and documented in written and illustrated reports.

MIP 602
Infrastructure Technology Studio II 6 credits
A comprehensive planning and design project emphasizing infrastructure technologies and information management. Interdisciplinary teams use CAD and other computer applications to produce computer-generated graphics and multi-media presentations.

MIP 603
Interdisciplinary Infrastructure Studio III 6 credits
The culmination of the studio sequence is a comprehensive infrastructure planning project developed with guidance from an interdisciplinary faculty group. Although subjects and approaches will vary, the work of the studio is intended to demonstrate the students' ability to deal with all facets of infrastructure planning regardless of previous background. The final products are submitted to public scrutiny and must include full graphic and written presentations of the project and a report on the research and development work on which it is based.

MIP 612
Introduction to Environmental Policy Studies 3 credits
Introduction to six areas essential to a comprehensive understanding of environmental policy: concept of environmental policy; tools (law, economics, planning, science, engineering, ethics) for environmental policy; the U.S. perspective (NEPA, clean air and water acts, CERCLA, etc.); the international perspective (Club of Rome models, 1972 UNEP, 1992 Rio, etc.); industrial perspective (pollution prevention/life cycle engineering, privatization, etc.); and the local perspective (New Jersey DEP, NGOs, local industry, shoreline, etc.). *Same as EPS 612.*

MIP 618
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as Fin 618 and Tran 604.*

MIP 631
History and Theory of Infrastructure 3 credits
The historical role of infrastructure in the formation of cities and the relation of planning theories to urban culture. Teams use case studies to develop effective ways of learning urban design; method and substance are equally emphasized. Concentration on the social, economic, political, technological and topographic factors that affect urban form; analysis of urban design schemata and their relation to patterns of use; and the critical appraisal of planning ideologies and strategies. *Same as Arch 631H.*

MIP 643
Introduction to Urban Transportation Planning 3 credits
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. *Same as CE 603 and Tran 603.*

MIP 650
Urban Systems Engineering 3 credits
Prerequisite: B.S. degree in engineering or in the physical or social sciences with some computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods,

mathematical modeling and simulation, and decision making under uncertainty. *Same as CE 650 and Tran 650.*

*MIP 668
Development of Urban Planning 3 credits
Urban planning in its historical context; the meaning of rationality in policy formulation; relation to social, economic and political processes; methods of theory formulation; problems of ensuring equity and democratic participation; introductory managerial issues including evaluation of the governmental context within which development and planning occurs. *Same as R26:834:501.*

*MIP 669
Infrastructure Financing and Strategy 3 credits
How to implement the financing of a capital improvement plan through a budget for infrastructure items such as streets, parks, public utilities, and other public works. Methods of financing, both short and long term, and a mix of markets in which funds might be sought. Emphasis on the latest financial tools created among investment banks in the public finance area. Fieldwork required. *Same as R26:834:569.*

MIP 673
Introduction to Infrastructure Planning 3 credits
An introduction to infrastructure planning principles, methods and tools. Through selected examples, acquaintance with infrastructure planning theories and models, quantitative methods of research and analysis, information management, decision making, and implementation techniques. *Same as Arch 673.*

MIP 674
Infrastructure and Architecture 3 credits
Examination of areas of overlap and continuity between architecture, landscape architecture, urban design, building science and infrastructure. Topics include the typology, programming and design of public facilities; the housing fabric; the relation between built form, urban space and infrastructure. *Same as Arch 674.*

MIP 675
Elements of Infrastructure Planning 3 credits
Introductory survey of the basic principles, operation and design of physical infrastructure systems including roads, public transportation, community facilities, public open space, surface drainage, and electric, gas, water, waste disposal, and telecommunications services. *Same as Arch 675.*

MIP 691
Legal and Ethical Issues 3 credits
Explores the legal and ethical responsibilities of managers. Analyzes extent to which shareholders should be allowed to exercise their legitimate economic, legal, and ethical claims on corporate managers; extent of regulation of a particular industry, individual rights of the employee and various corporate interests, and corporate responsibility to consumers, society, and conservation of natural resources and the environment. *Same as Mgmt 691.*

*NJIT designation pending

Management

Offered by the School of Industrial Management

Mgmt 580
Managerial Science 3 credits
Introduction to methods of operations research and systems analysis of managerial problems: objective functions and constraints, theories of values, optimization and simulation modeling with emphasis on models of production systems, decision analysis, inventory systems, project planning, and transportation systems. Deterministic and stochastic approaches to these topics are covered.

Mgmt 610
Foundations of Management in Organizations 3 credits
Presented during the residence week for the Executive Program. Includes management accounting, managerial economics, statistics, operations research, marketing, MIS, and finance.

Mgmt 620
Management of Technology 3 credits
Technology as a main component of an organizational entity. Generation, development, and implementation of technology are outlined. Influence of technology on global competitiveness is also discussed.

Mgmt 640
New Venture Management 3 credits
Prerequisite: Fin 516. For the student who is considering starting or managing a new business. The course combines classroom instruction in business management and a term project involving the analysis of a business case. The course is designed to build upon and integrate the student's previously acquired business knowledge and skills into an understanding of how to start and run a new business.

Mgmt 645
New Venture Finance 3 credits
Prerequisite: Fin 516. This course is designed to provide students with understanding of the problems and opportunities posed by the financing of a new and growing technology-based business. Students will study the financial conditions of new businesses and examine the effect of growth upon cash flow while exploring optimal sources of capital.

Mgmt 650
Leadership in Total Quality Management 3 credits
Presents an integrative approach to total quality management as it relates to achieving competitive and global advantage. Specific emphasis is placed on coordinating the marketing, production, service, and human resource function in TQM programs. The role of senior management in building organizations committed to TQM is then addressed.

Mgmt 655
Global Competitiveness 3 credits
Improves knowledge of the issues involved in international business operations and their management. Develops skills in selecting key issues and familiarization with emerging methods for organizing and managing international operations. Emphasis will be on companies with technological, product, production, or design focus.

Mgmt 657
Import/Export Processes 3 credits
Prerequisite: Mgmt 670 or Mgmt 655. Discusses key elements of import/export planning processes with an emphasis on the technology-based firm. International environment, market analysis, export strategy, and transactions are studied. Covers trade regulations and policies, financial advantage of foreign trade zones, and international standards for technology-based products. Factors underlying trade encouragement and restrictions between nations are also considered.

Mgmt 660
Global Communications 3 credits
Communications within a company, with its customers, and between its suppliers, is essential to business operations. Internationalization of suppliers and customers requires changes in traditional corporate communication systems. Models for design and management of global communication systems are presented and discussed. Emphasis is on improving the socio-technical operations interface. Topics include: use of telecommunications and related technologies for communications; new patterns of global business communications; and means to manage technological and cultural communication gaps.

Mgmt 665
International Product Development 3 credits
Prerequisite: Mgmt 670 or Mgmt 655. Students will learn about product development processes as part of international business development operations. Examines differences in developing products for: national and international customers, production and service industries, and static and dynamic client needs. Examines methods of design management, means to integrate product design, production, and marketing functions, and measures for product life-cycle accounting. Term projects examine national differences in product development.

Mgmt 670
International Business 3 credits
Covers the scope and the essential characteristics of international business in the world economy; MNEs as economic, political, and social institutions; national and international control; functional management and operations; country evaluation; and regional market analysis.

Mgmt 675
Legal Environment of International Business 3 credits
Focuses on the legal aspects of international business activities. Topics include: international trade practices and government regulations; legal aspects of international joint ventures, mergers, and acquisitions; and the legal component of intellectual property rights and its relation to trade disputes.

Mgmt 680
Entrepreneurial Strategy 3 credits
For the student who is considering starting and/or managing a new business. Integrates knowledge of the different aspects of business that have been learned as separate subjects. Provides an understanding of the decisions that guide the overall operations of an entrepreneurial business organization and how it interacts with its markets, competitors, and suppliers. Combines classroom instruction in business strategy along with case analysis of small firms. Should be taken in the last semester of the program, unless prior arrangement has been made with the instructor or the graduate advisor.

Mgmt 691
Legal and Ethical Issues 3 credits
Explores the legal and ethical responsibilities of managers. Analyzes extent to which shareholders should be allowed to exercise their legitimate economic, legal, and ethical claims on corporate managers; extent of regulation of a particular industry, individual rights of the employee and various corporate interests, and corporate responsibility to consumers, society, and conservation of natural resources and the environment. *Same as MIP 691.*

Mgmt 692
Business Strategy 3 credits
Prerequisites: Mgmt 691, HRM 601. Integration of the functional areas in management providing a top management perspective to the role of chief executive in an organization; strategy formulation and implementation; and ethical issues related to corporate strategies.

Mgmt 695
Business Strategy for Environmental Management 3 credits
This is a capstone course integrating the functional areas in management to provide a top management perspective to potential managers. The course deals with the role of the chief executive in environmental management and how strategies are formulated and implemented.

Mgmt 710
Business Forecasting Methods 3 credits
Covers the application of forecasting techniques to various phases of business and management decision making. Topics include forecasting with cyclical and seasonal series; Box-Jenkins modeling; regression modeling; use of stochastic models; and the linkage of management forecasts to macro forecasts. Actual models in use will be reviewed and evaluated.

Mgmt 791
Graduate Seminar Non-credit
Faculty, students and invited speakers present and discuss current topics of research in management.

Manufacturing Systems Engineering

Offered by the Department of Industrial and Manufacturing Engineering

MnE 601
Manufacturing Systems 3 credits
Modeling and control of large-scale systems with application to complex manufacturing systems including mathematically based modeling and control, and artificial intelligence-based methods.

MnE 602
Manufacturing Systems Integration 3 credits
Elements in the design and manufacture of consumer and industrial goods: information systems, CAE-CAD-CAM systems, retrofit techniques, software, design for automated manufacture, and other topics related to manufacturing system integration.

MnE 603
Management of Manufacturing Systems 3 credits
Methods of planning and control of manufacturing organization, processes and facilities including demand forecasting, product development, capacity planning, inventory control, site selection, finance development, decision processes, personnel development and training, and manufacturing policy formulation.

MnE 700
Master's Project I 3 credits, 1st or 2nd sem.
An interdisciplinary team project performed in collaboration with industry. The project must reflect proficiency in the student's selected area of specialization.

MnE 701
Master's Thesis 6 credits, 1st or 2nd sem.
In special cases, a thesis based on an important industrial problem will be substituted for the master's project. Research for the thesis should be performed with industrial sponsorship and collaboration.

MnE 702
Master's Project II
Same as MnE 700.

MnE 715
Selected Topics in Manufacturing Computer Systems Analysis and Design 3 credits
Prerequisite: approval of the program director. Topics in various areas of specialization.

MnE 716
Selected Topics in Automated Production Systems 3 credits
Prerequisite: approval of the program director. Topics vary according to student's area of specialization.

MnE 717
Selected Topics in System and Product Design 3 credits
Prerequisite: approval of the program director. Topics vary according to student's area of specialization.

MnE 718
Selected Topics in Manufacturing Management Systems 3 credits
Prerequisite: approval of the program director. Topics vary according to student's area of specialization.

MnE 719
Selected Topics in Computer Control of Manufacturing Systems 3 credits
Prerequisite: approval of the program director. Topics vary according to student's area of specialization.

MnE 725
Independent Study in Manufacturing Computer Systems Analysis and Design 3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in manufacturing computer systems analysis and design in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 726
Independent Study in Automated Production Systems 3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in automated production systems in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 727
Independent Study in System and Product Design 3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in system and product design, in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 728
Independent Study in Manufacturing Management Systems 3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in manufacturing management systems, in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 729
Independent Study in Computer Control of Manufacturing Systems 3 credits
Prerequisites: written permission from the director of manufacturing systems engineering programs, and courses prescribed by the supervising faculty member. Areas of study in computer control of manufacturing systems, in which one or more students may be interested, but that are not of sufficiently broad interest to warrant a regular course offering.

MnE 791
Manufacturing Engineering Seminar 1 credit
A series of invited speakers, primarily from industry, will discuss current manufacturing problems and methods. Attendance at these seminars is required for all students enrolled in the manufacturing systems engineering program.

Marketing Management

Offered by the School of Industrial Management

Mrkt 530
Principles of Marketing 3 credits
Examination of the factors relating to marketing process. The nature and significance of consumer and organization buying behaviors, competition, government regulations, consumerism, and social responsibility are analyzed. Covers decision making in market research, product development, pricing, distribution, advertising, promotion, selling, and marketing strategy.

Mrkt 630
Models of Consumer Behavior 3 credits
Provides students a framework, the buyer decision process model, to analyze how and why products and services are selected and purchased. Impact of consumer decisions on the marketing strategies of organizations is emphasized. Focus on total quality management of the marketing function that determines customer needs; provides the appropriate products, prices, distribution systems, and promotion messages; and measures customer satisfaction after purchase and use.

Mrkt 631
Market Planning and Analysis 3 credits
Provides a research and managerial perspective on advanced marketing research methods and analytical techniques. Topics include problem formulation, research design, data collection and analysis, managerial report writing. Students will acquire experience by developing and executing their own marketing research project using sophisticated computerized analytical techniques.

Mrkt 632
Marketing Strategy for Technology-Based Organizations 3 credits
Students combine the knowledge and skills learned in other marketing courses and develop strategic marketing plans that focus on total quality management, productivity improvement, and international competitiveness. Buyer decision making, market segmentation and targeting, product positioning, market response, and competitive actions are analyzed. Case studies and student projects add realism and practical experience to the course.

Mrkt 636
Design and Development of High Technology Products 3 credits
Focus on analysis of needs of buyers and consumers for specific product characteristics and the development of appropriate products to satisfy such needs. The process of identifying new product opportunities, screening new product concepts, product testing and test marketing, product positioning, and development of the marketing strategy and implementation plans.

Mrkt 637
Marketing Communications and Promotions 3 credits
Communications, sales promotion, and public relations are examined from the perspective of the manager. Topics include advertising and promotion research, media selection, creative production of electronic and print materials, and the budgeting and control of their use. Field research will be stressed as part of the course project requirement.

Mrkt 638
Sales Management for Technical Professionals 3 credits
Focuses on the promotion and sales of products in the business-to-organization market. All elements of the marketing communications mix are covered according to their importance in that market: selling, sales promotion, trade advertising, and publicity. The latest techniques are reviewed and discussed using case histories and student projects. Issues of global competitiveness, high technology products, and the role of total quality management in marketing communications are emphasized.

Mrkt 640
Industrial Marketing Management 3 credits
Stresses the role of the manager in all aspects of marketing. Managerial decision-making techniques and strategies for product development, product pricing, distribution channels, personal selling, advertising and promotion. Strategic and operational marketing plans are developed based on student field research.

Mrkt 642
International Marketing Management 3 credits
Focus on multinational enterprise in the global market, emphasizing special managerial skills required to adapt sound marketing practices to foreign cultural, political, economic and financial environments. Foreign opportunities and marketing strategies are examined. Students prepare a marketing plan for entry into an international market after conducting appropriate research.

Mrkt 701
Methods of Research in Marketing Management 3 credits
Prerequisites: Mrkt 630, Mrkt 631, Mrkt 632 or waived with approval of the Dean. For students who do a thesis in marketing. State-of-the-art marketing research methods: importance in marketing decision making, research objectives, research design, measurement concepts, reliability and validity, primary and secondary data collection, sampling design, qualitative and quantitative research and analytical methods, field studies and survey research, multivariate analytical models. Also covers planning, preparation and submission of the thesis.

*Mrkt 731
Advanced Market Planning and Analysis 3 credits
Covers advanced topics in the design and analysis of market research studies. Focus on the development of statistical sampling methods and techniques to develop estimates for complex marketing problems. Also focuses on advanced multivariate analysis and estimation techniques needed in the interpretation of complex marketing problems.

Mrkt 753
Marketing Science 3 credits
Emphasizes quantitative model building approach to the complex problems of marketing decision making using the principles of quantitative decisions to management problems and econometrics to the understanding of large amounts of data, which lead to improvements in marketing decision effectiveness. Such areas of marketing as buyer behavior, pricing, promotion, advertising, sales force management, and new product planning will be analyzed.

Materials Science and Engineering

Offered by Committee for the Interdisciplinary Program in Materials Science and Engineering

MtSE 605
Fundamentals of Engineering Materials 3 credits
Prerequisite: graduate standing. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and de-

*pending

fects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MtSE 610
Mechanical Properties of Materials 3 credits
Prerequisite: graduate standing. Elements of elasticity and plasticity theory, deformation and fracture behavior of materials, the concept of dislocations and their interaction with other lattice defects, strengthening mechanisms in solids, and principles of failure analysis. Materials to be studied include metals, polymers, ceramics, glasses, and composites.

MtSE 615
Composite Materials 3 credits
Prerequisites: MtSE 605 and MtSE 610. Introduction to fundamental principles of design and technology of composite materials. Materials based on polymer, ceramic, and metal matrices are discussed. Properties of the constitutive materials, their structure, methods of structural arrangements, as well as properties and characterization of the final products are described. The different perspectives, examples, and problems in composite applications are outlined.

MtSE 625
Introduction to Ceramics 3 credits
Prerequisite: MtSE 605. Mechanical, thermal, electrical, magnetic, and optical properties of crystalline and glassy ceramics are discussed from a structural viewpoint. Important processing methods, design and evaluation of properties, and modern applications of ceramic materials are emphasized.

MtSE 627
Glass Science and Engineering 3 credits
Prerequisites: MtSE 605 and MtSE 630. Formation and structure of inorganic, polymeric, and metallic glasses. Transport phenomena, kinetics of crystallization, glass transition, and phase separation; chemical, mechanical and optical properties of glasses.

MtSE 630
Thermodynamics of Materials 3 credits
Prerequisite: undergraduate thermodyamics. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MtSE 650
Physical Metallurgy 3 credits
Prerequisite: MtSE 605. Processing-structure-property relationships in metallic alloys. Alloy systems covered include carbon steels, stainless steels, aluminum and titanium alloys, and super alloys. Topics to be presented include elementary theory of metals, defects and related phenomena, soidification, phase phenomena, solid state diffusion, nucleation and growth kinetics, as well as transformation and deformation processes.

MtSE 655
Diffusion and Solid State Kinetics 3 credits
Prerequisite: MtSE 630. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MtSE 700
Master's Project 3 credits
Prerequisites: sufficient experience and/or graduate courses to work on the project and approval of project advisor. An extensive report involving an experimental, theoretical, or literature investigation is required. The literature investigation should result in a critical review of a specific area. Students may extend the Master's Project into a Master's Thesis.

MtSE 701
Master's Thesis 6 credits
Prerequisites: sufficient experience and/or graduate courses to work on the thesis and approval of thesis advisor. Research involving experimental or theoretical investigations or collaborative projects with industry or governmental agencies may be accepted. Completed work in the form of a written thesis should merit publication in a technical journal and must be approved by a committee consisting of three faculty members. A student must register for 3 credits per semester. Only the 6 credits indicated for the thesis will be applied to the degree.

MtSE 702
Characterization of Solids 3 credits
Current methods for characterizing the chemical composition, crystallographic structure, electrical mapping, and morphology of solid materials. Principles and application of Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), X-ray Photoelectron Spectroscopy (XPS), X-ray Emission Spectroscopy (XES), and Rutherford Backscattering Spectroscopy (RBS) for chemical analysis, X-ray Diffraction (XRD) and electron diffraction for crystallographic analysis, Electron Beam Induced Current (EBIC) microscopy, voltage contrast microscopy, Cathodoluminescence for electrical mapping, and Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) and Nomarski interference contrast microscopy (DIC) for morphology.

MtSE 725
Crystallography and Diffraction 3 credits
Prerequisite: graduate standing. The atomic arrangement of crystalline materials including treatment of crystalline defects and diffraction phenomena. Lattices, crystal systems, symmetry operations are covered as well as the fundamentals of electron and X-ray diffraction.

MtSE 737
Transport of Electrons and Phonons in Solids 3 credits
Prerequisite: Phys 687/26:755:687. Basic transport processes involving electrons and phonons in solids. Topics inlcude transport-related phenomena such as Hall effect, quantum Hall effect, magneto-resistance, size effects, thermal conductivity, thermoelectric effects, phonon drag, ballistic phonons, and ballistic electrons. Applications of transport to the characterization of new electronic materials including thin films are stressed.

MtSE 757
Defects in Solids 3 credits
Prerequisites: MtSE 605 and MtSE 725. Crystallographic defects in solids, namely point defects such as vacancies and interstitial, line defects such as dislocations, and planar defects such as grain boundaries. Correlation of these defects to the mechanical, electrical and optical behavior of materials is examined in particular. Experimental methods for observation and characterization of defects including TEM, EBIC, DLTS, etc. are described.

MtSE 765
Science and Technology of Thin Films 3 credits
Prerequisite: graduate standing. Methods of preparing thin films by physical and chemical means are examined. Topics pertinent to nucleation and growth mechanism of single and polycrystalline films, structure determination, film thickness and compositional evaluation properties are discussed. The electrical, magnetic, optical, and mechanical properties of metallic, semiconductor, and insulating thin films are studied with particular relevance to integrated circuit applications.

MtSE 790
Doctoral Dissertation and Research Credits as designated
Required of all candidates for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Students must register for 6 credits each semester until 36 credits are reached. If the dissertation is not yet complete, registration for an additional 3 credits is required each semester thereafter.

MtSE 791
Graduate Seminar Non-credit
Required of all students enrolled in the M.S. or Ph.D. Program in Materials Science and Engineering. Faculty, students, and invited speakers will present and discuss current topics of research in materials science and engineering.

MtSE 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of the director of the M.S./Ph.D. in Materials Science and Engineering program. For students enrolled in the Ph.D. program before passing the Ph.D. qualifying examinations. Research is carried out under the supervision of a faculty member of the student's choice. A maximum of 6 credits may be applied to MtSE 790.

Mathematics

Offered by the Department of Mathematics

Math 545
Advanced Calculus I 3 credits
Prerequisite: undergraduate calculus. Rigorous treatment of the calculus of real-valued functions of one real variable: the real number system, Epsilon-Delta theory of limit, continuity, derivative, and the Riemann integral. The fundamental theory of calculus. Series and sequences including Taylor series and uniform convergence. The inverse and implicit function theorems.

Math 546
Advanced Calculus II 3 credits
Prerequisite: Math 545 or equivalent. Rigorous treatment of the calculus of real-valued functions of several real variables: the geometry and algebra of n-dimensional Euclidean space. Limit, continuity, derivative, and the Riemann integral of functions of several variables. The inverse and implicit function theorems. Series, including Taylor series. Optimization problems. Integration on curves and surfaces, the divergence and related theorems.

Math 551
Engineering Mathematics 3 credits
Prerequisite: undergraduate differential equations. Mathematical methods useful in the analysis of problems arising in applied mathematics and engineering. Topics include Fourier series, general orthogonal systems, Laplace and Fourier transforms, boundary-value problems, generalized functions, linear algebra and systems of ordinary differential equations.

Math 560
Methods of Applied Mathematics I
3 credits
Prerequisite: Math 331, Math 337, Math 545 or departmental approval. This course introduces relevant problems and techniques in applied mathematics. This includes basic problems in linear algebra, and ordinary and partial differential equations.

Math 561
Methods of Applied Mathematics II
3 credits
Prerequisite: Math 560. This course is a continuation of Math 560. Topics include Green's functions, scattering, spectral theory, characteristics and conservation laws. Applications to fluid and gas dynamics, traffic flow and mathematical biology will be treated.

Math 573
Intermediate Differential Equations
3 credits
Prerequisites: undergraduate differential equations and linear algebra. Methods and applications for systems of ordinary differential equations: existence and uniqueness for solutions of ODEs, linear systems, and stability analysis. Phase plane and geometrical methods. Sturm-Louville eigenvalue problems.

Math 590
BS/MS Co-op Work Experience I
3 additive credits
Prerequisites: enrollment and standing in the BS/MS program, and permission from mathematics department and co-op office. Cooperative education/internship providing on-the-job complement to academic programs in mathematics. Work assignments and projects are developed by the co-op office in consultation with the mathematics department.

Math 591
BS/MS Co-op Work Experience II
3 additive credits
Prerequisites: Math 590, and permission from mathematics department and co-op office. Continuation of Math 590.

Math 592
Co-op Work Experience III 3 additive credits
Prerequisites: Math 591, graduate status and permission from mathematics department and Office of Cooperative Education and Internships. Continuation of Math 591.

Math 599
Teaching in Mathematics 3 credits
Prerequisite: full-time status in a graduate program. This course provides TA's in mathematics with the skills and practice necessary for the effective performance of teaching and related duties. Students are exposed to strategies and methods for teaching undergraduate mathematics, and are required to demonstrate their capability for teaching using techniques. Not counted toward degree credit.

Math 611
Numerical Methods for Computation
3 credits
Prerequisites: undergraduate differential equations, linear algebra and familiarity with a computer language (FORTRAN, C, or equivalent). A practical introduction to the numerical methods of science and engineering. Numerical solution of a linear system. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for ODEs. Introduction to numerical solution of PDEs. Includes examples requiring student use of a computer with some use of software packages.

Math 613
Advanced Applied Mathematics I: Modeling 3 credits
Prerequisites: undergraduate differential equations and linear algebra. Concepts and strategies of mathematical modeling are developed by investigation of case studies in a selection of areas. Consistency of a model, nondimensionalization and scaling, regular and singular effects are discussed. Possible topics include continuum mechanics, vibrating strings, population dynamics, traffic flow, and the Sommerfeld problem.

Math 614
Numerical Methods I 3 credits
Prerequisites: undergraduate differential equations, linear algebra and familiarity with a computer language (FORTRAN, C, or equivalent). Theory and techniques of scientific computation, with more emphasis on accuracy and rigor than Math 611. Machine arithmetic. Numerical solution of a linear system and pivoting. Interpolation and quadrature. Iterative solution of nonlinear systems. Computation of eigenvalues and eigenvectors. Numerical solution of initial and boundary value problems for systems of ODEs. Applications. The class includes examples requiring student use of a computer.

Math 621
Applied Exterior Calculus 3 credits
Prerequisites: undergraduate calculus and linear algebra. Development of exterior calculus: the method of characteristics, first order linear and quasilinear PDEs and systems of PDEs. Lie subalgebras and reduction to Jacobi normal form. Theorems of Froebenius, Darboux, and Cartan. Antiexact forms and solution of exterior differential equations. Applications to nonlinear second order PDEs, calculus of variations, and examples from physics.

Math 630
Linear Algebra and Applications 3 credits
Prerequisites: undergraduate calculus and differential equations. Development of the concepts needed to study applications of linear algebra and matrix theory to science and engineering. Topics include linear systems of equations, matrix algebra, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition.

Math 631
Linear Algebra 3 credits
Prerequisites: undergraduate calculus and differential equations. Similar in aim and content to Math 630 but with more emphasis on mathematical rigor. Linear systems of equations, matrix algebra, linear spaces, orthogonality, eigenvalues and eigenvectors, diagonalization, and matrix decomposition. Applications.

Math 645
Analysis I 3 credits
Prerequisite: a background in advanced calculus. Review and extension of the fundamental concepts of advanced calculus: the real number system, limit, continuity, differentiation, the Riemann integral, sequences and series. Point set topology in metric spaces. Uniform convergence and its applications.

Math 651
Applied Mathematics I 3 credits
Prerequisite: undergraduate ordinary differential equations. A survey of mathematical methods for the solution of problems in the applied sciences and engineering. Topics include: ordinary differential equations, Fourier series, Fourier and Laplace transforms, and eigenfunction expansion.

Math 652
Applied Mathematics II 3 credits
Prerequisite: Math 651 or equivalent. Continuation of Math 651. Topics include: partial differential equations, functions of a complex variable, and the calculus of variations.

Math 656
Complex Variables I 3 credits
Prerequisite: undergraduate calculus. The theory and applications of analytic functions of one complex variable: elementary properties of complex numbers, analytic functions, elementary complex functions, conformal mapping, Cauchy integral formula, maximum modulus principle, Laurent series, classification of isolated singularities, residue theorem and applications.

Math 660
Differential Geometry of Curves and Surfaces II 3 credits
Prerequisites: Math 460 or equivalent. Differential forms, the Euler characteristic, the Gauss-Bonnet theorem, and the fundamental group. Outline of the topological classification of compact surfaces, vector fields, geodesics, and Jacobi fields. Calculus of variations. The global differential geometry of surfaces and the elementary theory of Riemann surfaces.

Math 661
Applied Statistics 3 credits
Prerequisite: undergraduate calculus. Data collection, elementary sampling methods and experimental design, descriptive statistics, summary measures for quantitative and qualitative data, graphical data analysis. Computational statistical inference, confidence intervals and tests on sample means, variances, and proportions. Curve fitting, lines, curves, and surfaces using least squares, data transformation, inference for curve fitting analysis, one-way and two-way ANOVA, Shewhart control charts.

Math 662
Mathematical Statistics I 3 credits
Prerequisite: a background in undergraduate statistics. Probability, conditional probability, random variables and distributions, independence, expectation, moment generating functions, special distributions, sampling distributions, the central limit theorem.

Math 668
Probability Theory 3 credits
Prerequisite: Math 662 or equivalent. Introduction to measure theory and integration, axiomatic probability, random variables, distribution function, expectation, independence, modes of convergence, characteristic functions, sums of identically distributed random variables, conditional expectation.

Math 671
Asymptotic Methods I 3 credits
Prerequisite: Math 545 or Math 645, Math 656, or equivalent. Asymptotic sequences and series. Use of asymptotic series. Regular and singular perturbation methods. Asymptotic methods for the solution of ODEs, including: boundary layer methods and asymptotic matching, multiple scales, the method of averaging, and simple WKB theory. Asymptotic expansion of integrals, including: Watson's lemma, stationary phase, Laplace's method, and the method of steepest descent.

Math 672
Biomathematics I: Biological Waves and Oscillations 3 credits
Prerequisites: differential equations and linear algebra, or permission of the instructor. Models of wave propagation and oscillatory phenomena in nerve, muscle, and arteries: Hodgkin-Huxley theory of nerve conduction, synchronization of the cardiac pacemaker, conduction and rhythm abnormalities of the heart, excitation-contraction coupling, and calcium induced waves, wave propagation in elastic arteries, models of periodic human locomotion.

Math 673
Biomathematics II: Pattern Formation in Biological Systems 3 credits
Prerequisites: differential equations and linear algebra, or permission of the instructor. Emergence of spatial and temporal order in biological and ecological systems: Hopf and Turing bifurcation in reaction-diffusion systems, how do zebras get their stripes, patterns on snake skins and butterfly wings, spatial organization in the visual cortex, symmetry breaking in hormonal interactions, how do the ovaries count. Basic techniques of mathematics are introduced and applied to significant biological phenomena that cannot be fully understood without their use.

Math 675
Partial Differential Equations 3 credits
Prerequisite: Math 690 or equivalent. A survey of the mathematical theory of partial differential equations: first order equations, classification of second order equations, the Cauchy-Kovalevsky theorem, properties of harmonic functions, the Dirichlet principle. Initial and boundary value problems for hyperbolic, elliptic, and parabolic equations. Systems of equations.

Math 676
Advanced Ordinary Differential Equations 3 credits
Prerequisites: undergraduate differential equations and Math 545 or equivalent. A rigorous treatment of the theory of systems of differential equations: existence and uniqueness of solutions, dependence on initial conditions and parameters. Linear systems, stability, and asymptotic behavior of solutions. Nonlinear systems, perturbation of periodic solutions, and geometric theory of systems of ODEs.

Math 677
Calculus of Variations 3 credits
Prerequisite: Math 676 or equivalent. Necessary conditions for existence of extrema. Variation of a functional, Euler's equation, constrained extrema, first integrals, Hamilton-Jacobi equation, quadratic functionals. Sufficient conditions for the existence of extrema. Applications to mechanics.

Math 683
Functional Analysis 3 credits
Prerequisite: Math 645 or equivalent. Principles of linear analysis: Hahn-Banach, uniform boundedness and closed graph theorems. Riesz representation theorem; weak topologies; Riesz theory of compact operators. Spectral theory of operators on Hilbert space. Applications to differential and integral equations.

Math 685
Combinatorics 3 credits
Prerequisite: Math 545 or equivalent. Generating functions, principle of inclusion-exclusion, pigeonhole principle, partitions. Polya's theory of counting, graph theory and applications.

Math 687
Quantitative Analysis for Environmental Design Research 3 credits
Prerequisites: college level statistics course and permission of instructor. Fundamental concepts in the theory of probability and statistics including descriptive data analysis, inferential statistics, sampling theory, linear regression and correlation, and analysis of variance. Also includes an introduction to linear programming and nonlinear models concluding with some discussion of optimization theory.

Math 689
Advanced Applied Mathematics II: ODEs 3 credits
Prerequisites: Math 545 and Math 631, or equivalent. A practical and theoretical treatment of boundary value problems for ordinary differential equations: generalized functions, Green's functions, spectral theory, variational principles, and allied numerical

procedures. Examples will be drawn from applications in science and engineering.

Math 690
Advanced Applied Mathematics III: PDEs 3 credits
Prerequisite: Math 689 or equivalent. A practical and theoretical treatment of initial and boundary value problems for partial differential equations: Green's functions, spectral theory, variational principles, transform methods, and allied numerical procedures. Examples will be drawn from applications in science and engineering.

Math 691
Stochastic Processes with Applications 3 credits
Prerequisite: Math 662 or equivalent. Renewal theory, renewal reward processes and applications. Homogeneous, non-homogeneous and compound Poisson processes with illustrative applications. Introduction to Markov chains in discrete and continuous time with selected applications.

Math 698
Sampling Theory 3 credits
Prerequisite: Math 662 or equivalent. Role of sample surveys. Sampling from finite populations, the conceptual framework. Sampling designs, the Horowitz-Thompson estimator of the population mean. Different sampling methods, simple random sampling, stratified sampling, ratio and regression estimates, cluster sampling, systematic sampling.

Math 699
Design and Analysis of Experiments 3 credits
Prerequisite: Math 662 or equivalent. Statistically designed experiments and their importance in data analysis, industrial experiments. Role of randomization. Fixed and random effect models and ANOVA, block design, latin square design, factorial and fractional factorial designs and their analysis.

Math 700
Master's Project 3 credits
Prerequisites: matriculation for the master's degree and departmental approval. Work must be initiated with the approval of a faculty member, who will be the student's project advisor. Work of sufficient quality may qualify for extension into a master's thesis, see Math 701.

Math 701
Master's Thesis 6 credits
Prerequisite: matriculation for the master's degree and departmental approval. A student must register for a minimum of 3 credits per semester until completion. The work will be carried out under the supervision of a designated member of the faculty.

Math 707
Advanced Applied Mathematics IV: Special Topics 3 credits
Prerequisite: permission of the instructor. A current research topic of interest to departmental faculty. Typical topics include: computational fluid dynamics, theoretical fluid dynamics, acoustics, wave propagation, dynamical systems, numerical analysis and scientific computation, theoretical and numerical aspects of combustion, and various topics in statistics.

Math 711
Logic and Set Theory 3 credits
Prerequisite: permission of the instructor. Propositional calculus, predicate calculus, first-order theories and concepts of consistency, completeness and decidability. Theorems of Church, Kleene, Godel, Mostowski and Turing. Axiomatic set theory according to von Neumann, Bernays, Godel, and others. Recursive functions, effective computability and Turing machines.

Math 712
Numerical Methods II 3 credits
Prerequisites: Math 614 and introductory partial differential equations, or equivalent. Numerical methods for the solution of initial and boundary value problems for partial differential equations, with emphasis on finite difference methods. Consistency, stability, convergence, and implementation are considered.

Math 720
Tensor Analysis 3 credits
Prerequisite: permission of the instructor. Review of vector analysis in general curvilinear coordinates. Algebra and differential calculus of tensors. Applications to differential geometry, analytical mechanics and mechanics of continuous media. The choice of applications will be determined by the interests of the class.

Math 730
Applied Algebra 3 credits
Prerequisite: Math 631 or equivalent. An introduction to groups, rings, fields and their applications in science and engineering. Topics that are usually emphasized include permutation groups, cyclic groups, polynomial algebras and finite fields.

Math 745
Analysis II 3 credits
Prerequisite: Math 645 or equivalent. Lebesgue measure and integration, including the Lebesgue dominated convergence theorem and Riesz-Fischer theorem. Elements of Hilbert spaces and L^p-spaces. Fourier series and harmonic analysis. Multivariate calculus.

Math 756
Complex Variables II 3 credits
Prerequisite: Math 656 or equivalent. Selected topics from: conformal mapping and applications of the Schwarz-Christoffel transformation; applications of calculus of residues; singularities, principle of the argument, Rouché's theorem, Mittag-Lefler's theorem, Casorati-Weierstrass theorem; analytic continuation and applications, Schwarz reflection principle, monodromy theorem, Wiener-Hopf technique; asymptotic expansion of integrals; integral transform techniques; special functions.

Math 761
Statistical Reliability Theory and Applications 3 credits
Prerequisite: Math 662 or equivalent. Survival distributions, failure rate and hazard functions, residual life. Common parametric families used in modeling life data. Introduction to nonparametric ageing classes. Coherent structures, fault tree analysis, redundancy and standby systems, system availability, repairable systems, selected applications such as software reliability.

Math 762
Mathematical Statistics II 3 credits
Prerequisite: Math 662 or equivalent. Estimation and hypothesis testing. Sufficiency, completeness, Rao-Cramer inequality, Neyman-Pearson lemma; uniformly most powerful tests, nonparametric tests and likelihood ratio tests. Regression and correlation, analysis of variance.

Math 771
Asymptotic Methods II 3 credits
Prerequisite: Math 671 or equivalent. Continuation of Math 671. Asymptotic methods for the solution of PDEs, including: matched asymptotic expansions, multiple scales, the WKB method or geometrical optics, and near-field far-field expansions. Applications to elliptic, parabolic, and hyperbolic problems. Further topics in the asymptotic expansion of integrals and the WKB method. Emphasis on examples drawn from applications in science and engineering.

Math 790
Doctoral Dissertation and Research Credits as designated
Prerequisite: completion of the doctoral qualifying examination. A minimum of 36 credits is required of all candidates for the Ph.D. degree. Registration between a minimum of 6 credits per semester and a maximum of 12 credits per semester is determined by a designated thesis advisor. When 36 credits are reached, students must continue to register for 3 credits each semester until degree completion.

Math 791
Graduate Seminar Non-credit
Required each semester of all doctoral students and master's students receiving departmental or research-based awards.

Math 792
Pre-Doctoral Research 3 credits
Prerequisite: departmental approval. For students admitted to the program leading to the degree of Ph.D. in the mathematical sciences. Research is performed under the supervision of a designated faculty member. If the work culminates in doctoral research in the same area, up to 6 credits may be counted toward Math 790. See Math 790.

Mechanical Engineering

Offered by the Department of Mechanical Engineering

ME 590
BS/MS Co-op Work Experience I
3 additive credits
Prerequisites: standing and acceptance in the combined BS/MS program and permission from Department of Mechanical Engineering and Office of Cooperative Education and Internships. Cooperative education internship providing on-the-job reinforcement of academic programs in mechanical engineering. Work assignments and projects are developed by the co-op office in consultation with the mechanical engineering department. Work assignments are related to student's major and are evaluated by faculty coordinators in mechanical engineering. Course cannot be used for mechanical engineering degree credit.

ME 591
BS/MS Co-op Work Experience II
3 additive credits
Prerequisites: ME 590 and permission from Department of Mechanical Engineering and Office of Cooperative Education and Internships. Continuation of ME 590. Course cannot be used for mechanical engineering degree credit.

ME 592
Co-op Work Experience III
3 additive credits
Prerequisites: ME 591, graduate standing, and permission from Department of Mechanical Engineering and Office of Cooperative Education and Internships. Continuation of ME 591. Course cannot be used for mechanical engineering degree credit.

ME 607
Advanced Thermodynamics 3 credits
Prerequisite: undergraduate thermodynamics. Basic laws of thermodynamics applied to various thermodynamic systems. Topics include general thermodynamic relationships for single and multicomponent systems, stability, phase and chemical equilibrium, thermal stress, surface tension phenomena, gas liquefaction, magnetic cooling, superconductivity, and negative Kelvin temperatures.

ME 608
Non-Equilibrium Thermodynamics
3 credits
Prerequisites: undergraduate thermodynamics and heat transfer. Principles and mathematical techniques of non-equilibrium thermodynamics applied to mechanical engineering problems. Topics include field theory, energy and entropy balances, variational principles, and applications to fluid flow, heat exchangers and combustion.

ME 609
Dynamics of Compressible Fluids
3 credits
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. One-dimensional reversible and irreversible compressible fluid flow, including effects of variable area, friction, mass addition, heat addition, and normal shock; two-dimensional reversible subsonic and supersonic flows, and an introduction to the method of characteristics and two-dimensional oblique shock.

ME 610
Applied Heat Transfer 3 credits
Prerequisites: undegraduate fluid mechanics, heat transfer, and ME 616 or equivalent. Fundamentals of conduction, convection and radiation heat transfer. Practical engineering applications of heat exchangers including the design approaches by Mean Temperature Difference and Effectiveness-NTU methods, fins, convection fouling factors, and variable property analysis.

ME 611
Dynamics of Incompressible Fluids
3 credits
Prerequisites: undergraduate fluid mechanics, and ME 616 or equivalent. An introduction to the hydrodynamics of ideal fluids; two-dimensional potential flow and stream functions; conformal mapping; and differential equations of viscous flow. Boundary layer theory and dimensional analysis are introduced.

ME 612
Gas Dynamics 3 credits
Prerequisite: ME 616 or equivalent. Physical phenomena of gas dynamics and mathematical methods and techniques needed for analysis. Dynamic and thermodynamic relations for common flow situations are described through vector calculus. The nonlinearity of resulting equations and solutions such as numerical analysis, linearization or small perturbation theory, transformation of variables, and successive approximations are discussed. The method of characteristics is reviewed in detail for shock flows.

ME 613
Radiation Heat Transfer 3 credits
Prerequisites: undergraduate differential equations, thermodynamics, and heat transfer. Heat radiation of solid bodies, gases and flames; angle factors; radiative properties of electrical conductors and non-conductors; application of radiative networks to multibody problems; diffuse specular reflectors: artificial satellites and space vehicles; analogy between heat transfer by radiation and electrical networks; and combined conduction and radiation problems.

ME 615
Advanced Mechanical Vibrations 3 credits
Prerequisites: undergraduate vibrations and differential equations. Advanced principles of vibration: Lagrange's equation of motion, field balancing, matrix notation and iteration procedure, influence coefficients, and Fourier series representation for the solution of vibration problems.

ME 616
Matrix Methods in Mechanical Engineering
3 credits
Prerequisite: undergraduate differential equations. Applications of matrix algebra and matrix calculus to engineering analysis; matrix methods in solid and fluid mechanics; elasticity, plates and shells, viscous fluids, and curvilinear coordinates. Matrix theory is used to show the basic unity in engineering analysis.

ME 617
Random Vibration 3 credits
Prerequisites: strength of materials, mechanical vibrations, and ME 616 or equivalent. An extension of classical vibration theory to problems of random excitation. Includes analysis of vibration response utilizing the mobility and impedance of mechanical components and spectral density representations. Nonlinear vibration and design for shock are also considered.

ME 618
Selected Topics in Mechanical Engineering 3 credits
Prerequisite: departmental approval. Given when interest develops. Topics may include analysis and/or design of energy or mechanical systems of current interest to mechanical engineers.

ME 620
Stress Methods in Mechanical Design
3 credits
Prerequisites: undergraduate differential equations and strength of materials. Governing equations and solutions for analysis and design of structural and machine elements; appropriate boundary conditions to investigate pipes and rods subjected to shrink and force fits; rotating disks of uniform and variable thickness; beam and plate elements; and thermal stresses and stress concentrations in mechanical design.

ME 621
Energy Methods in Mechanical Design
3 credits
Prerequisites: undergraduate differential equations and strength of materials. Use of energy methods to design structural and machine elements. Included are approximate solutions for problems using conservation of energy and variational approaches; the role of energy in failure criteria; combined loads; and the relationship of variational methods to the development of finite element solutions.

ME 622
Finite Element Methods in Mechanical Engineering 3 credits
Prerequisites: undergraduate differential equations and strength of materials. Using variational formulation and Ritz approximation, element equations for bar, beam, potential flow, heat transfer, torsion of a solid bar and plane elasticity problems are derived and solved with PC programs.

ME 624
Microlevel Modeling in Particle Technology 3 credits
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first two parts concern the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. *Same as ChE 625.*

ME 625
Introduction to Robotics 3 credits
Prerequisites: undergraduate differential equations, kinematics and demonstrated competence in computer programming. Introduction to robotics, and computer-controlled programmable robotic manipulators; robot geometries; kinematics of manipulators; differential motion; work space planning and trajectory control; dynamics; robot sensing, and robot programming.

ME 626
Corrosion 3 credits
General modes and theories of corrosion. Factors in nature, manufacturing and material properties that influence corrosion. Simplified theory and practical applications for engineers illustrating the causes and treatment of corrosion problems.

ME 628
Machine Vision Principles and Applications 3 credits
Prerequisites: undergraduate differential equations and demonstrated competence in computer programming. Fundamentals of machine vision as applied to inspection, recognition, and guidance in mechanical and manufacturing processes. Emphasis on real-time machine vision algorithms for machine parts inspection and identification. Topics include lighting and optics, camera selection and calibration, image segmentation, edge detection, feature extraction, and pattern classification.

ME 630
Analytical Methods in Machine Design 3 credits
Prerequisites: undergraduate differential equations, machine design, and ME 616 or equivalent. Theory and analytical methods used in machine design. Comparisons are made between approximate and exact engineering methods for evaluation of the range of applicability of solutions. Topics include advanced analysis of threaded members; keyed, splined, and shrink fits when subjected to torque; preloaded bearings; surging, presetting and buckling of coiled springs; and accurate analysis of impact stresses and stresses beyond the yield point.

ME 631
Bearings and Bearing Lubrication 3 credits
Prerequisites: undergraduate differential equations and machine design. The theoretical and physical aspects of lubrication: hydrostatic and hydrodynamic problems. Reynold's differential equation for pressure distribution applied to slider bearing and journal bearing problems with and without end leakage.

ME 632
Instrumentation 3 credits
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. Primary elements of instrumentation such as pressure, temperature, force, and speed measuring elements. Emphasis is placed on the analysis of instrumentation error, response time for dynamic measurement, and application of instrumentation in the fields of mechanics and thermal sciences.

ME 633
Dynamics of Machinery 3 credits
Prerequisites: undergraduate differential equations, machine design, and ME 616 or equivalent. Mechanical elements, linkages, cams, gears, and miscellaneous mechanisms; dynamic considerations, including inertia and gyroscopic effects commonly encountered in the design of automatic machinery and control mechanisms; impulse loads and transient conditions of motion; mechanical computing devices.

ME 635
Computer-Aided Design 3 credits
Prerequisite: demonstrated competence in computer programming. Adaptation of the digital computer for solving engineering design problems; design morphology; simulation and modeling; algorithms; problem-oriented languages; use of available software; computer graphics, and automated design.

ME 636
Mechanism Design: Analysis and Synthesis 3 credits
Prerequisites: undergraduate kinematics, dynamics and demonstrated competence in computer programming. Kinematic principles combined with computer-assisted methods for designing mechanisms; complex polar notation; and dynamic and kinetostatic analysis of mechanisms. Kinematic synthesis of planar mechanisms; graphical Burmester theory for plane linkage synthesis; and planar linkage synthesis for function and path generation.

ME 637
Kinematics of Spatial Mechanisms 3 credits
Prerequisites: undergraduate kinematics, dynamics and knowledge of matrices. Advanced techniques for the dual-number coordinate-transformation matrix modeling to perform the displacement, velocity, static and dynamic force analysis of spatial mechanisms. Applications considered will include shaft couplings, skew four-bars, wobble plates, generalized slider-cranks and robotic manipulators.

ME 638
Computer-Aided Machining 3 credits
Prerequisite: demonstrated competence in computer programming. Introduction of computer applications to understand the integration of CAD and CAM. Included in the course are the principles of numerical control, communications using MAP/TOP and LAN, flexible manufacturing systems, and the concept of the workcell. Student projects are carried out using appropriate manufacturing software.

ME 639
Combustion Engine Emissions and Their Control 3 credits
Prerequisite: undergraduate thermodynamics. Gasoline and diesel engines. Engine design, combustion, and emission formulation; homogeneous combustion of the gasoline engine and heterogeneous combustion of the diesel engine. Present and future emission control techniques; and experiments and demonstrations of fuel characteristics, engine performance, and exhaust emissions.

ME 640
Gas Turbines 3 credits
Prerequisites: undergraduate courses in differential equations and fluid mechanics (including compressible flow) or equivalent. Design and development of gas turbine power plants for stationary and mobile applications; power plant cycles and components; compressors, combustors, turbines, nozzles and interconnecting passages.

ME 641
Refrigeration and Air Conditioning 3 credits
Prerequisites: undergraduate differential equations, fluid mechanics and thermodynamics. Refrigeration and air conditioning cycles; comfort analysis, psychometric chart analysis, heat and mass transfer steady and transient processes, heating and cooling design loads, energy loads and standards requirements.

ME 642
Power Plant Design 3 credits
Prerequisites: undergraduate fluid mechanics and thermodynamics. Modern power plant cycles, including heater arrangements and heat balances. Effect of thermal and atmospheric discharges of modern generating facilities; predicting performance of generated equipment by shortcut methods; economics of auxiliaries; and the theory and practical application of incremental loading and rates. A systems approach to the use of fuel energy for the future is considered.

ME 643
Combustion 3 credits
Prerequisites: undergraduate thermodynamics and fluid mechanics. Chemical and physical process of combustion: ideal combustion, actual combustion, mass balance, energy of reaction, maximum adiabatic combustion temperature, chemical equilibrium, heating values of fuels, combustion in furnaces, internal combustion engines and other heat engines, with emphasis on the analysis and control of the products of combustion in light of environmental considerations.

ME 644
Building Environmental Control Principles 3 credits
Prerequisites: undergraduate thermodynamics, fluid mechanics, heat transfer and differential equations. Control systems for buildings including control of temperature, moisture and air quality. Optimization of systems for control of building energy use. Modern microprocessor-based control systems, including direct digital control, proportional and integral controllers, predictive control, adaptive control, optimum start controllers and optimal control.

ME 650
Experimental Stress Analysis 3 credits
Prerequisites: undergraduate differential equations and strength of materials. Experimental methods for analyzing stress and strain distributions. Static, dynamic, and residual stress distributions are examined using brittle lacquers, strain gauges, and related instrumentation; photoelastic methods and related theory. Current developments in theory and techniques are applied to the solution of special problems.

ME 653
Control of Electro-Mechanical Networks 3 credits
Prerequisites: undergraduate electrical circuits and mechanical vibrations or equivalent. Electro-mechanical systems; control loops; use of mechanical networks in dynamic systems; and stability and response to various inputs in electro-mechanical networks.

ME 655
Introduction to Modern Control Methods 3 credits
Prerequisites: undergraduate system dynamics and automatic controls. Introduction to modern control methods applied to mechanical and manufacturing systems. Topics include state variable feedback, observer theory, nonlinear control, optimal control, and adaptive control for both continuous and discrete systems.

ME 656
Piping Stress Analysis 3 credits
Prerequisites: undergraduate strength of materials and computer programming. Stress analysis of power plant piping; flexibility analysis; simplified analysis of thermal, dead weight and seismic loads on piping systems; ANSI/ASME B31.1 and ASME BPVC Section III code equations; and other applications.

ME 660
Noise Control 3 credits
Prerequisites: undergraduate differential equations and physics. Engineering methods for reducing noise pollution; reduction of intensity at the source; limitation of transmission paths and absorption; application to structures, machinery, ground transportation, aircraft, and noise measurement.

ME 661
Thermal Pollution of Water and Air 3 credits
Prerequisites: undergraduate differential equations, fluid mechanics, and thermodynamics. Effect of thermal pollution on the environment: heat exchange between water and air; thermal pollution of rivers, streams, lakes and reservoirs; design of cooling ponds and towers; and use of instruments and techniques in thermal pollution control studies.

ME 662
Air Pollution Control and Design 3 credits
Prerequisite: undergraduate thermodynamics. Techniques for the solution of air pollution problems; and equipment to control gaseous and particulate pollutants such as filters, precipitators, scrubbers, and absorption systems. A term project involving mechanical design is required.

ME 670
Introduction to Biomechanical Engineering 3 credits
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment.

ME 671
Biomechanics of Human Structure and Motion 3 credits
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

ME 675
Mechanics of Fiber Composites 3 credits
Prerequisites: ME 315 (see undergraduate catalog for course description) and demonstrated competence in computer programming. Introduces various design problems using fiber composites. Analysis of general fiber composite laminate and short fiber composites, fracture mechanics, fatigue, creep and viscoelasticity, thermal stresses, special layups and associated optimization problems.

ME 676
Applied Plasticity 3 credits
Prerequisite: ME 620 or equivalent. Fundamentals of plasticity applied to mechanical and manufacturing engineering problems. Topics include elastic-plastic analysis for beams, rings and plates. Plastic instability and slip-line fields are considered.

ME 678
Engineering Design of Plastic Products 3 credits
Prerequisite: ME 316 or equivalent. Structure and properties of plastics including stress-strain behavior and the effect of fillers and reinforcements. Designing for impact, flexure, shear, friction, puncture, creep and fatigue. Case studies of structural, electrical, and optical applications.

ME 679
Polymer Processing Techniques 3 credits
Prerequisites: undergraduate courses in fluid dynamics and heat transfer. Techniques for processing of plastics: extrusion, injection molding, compression molding, thermoforming, casting, etc.

ME 680
Polymer Processing Equipment 3 credits
Prerequisites: ChE 645 or equivalent and undergraduate heat transfer. Application of heat transfer, fluid mechanics, and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, collandering, rotational molding, stamping, and injection molding.

ME 700
Master's Project 3 credits
Prerequisite: department approval. An extensive paper involving design, construction, and analysis, or theoretical investigation. Further information may be obtained from the department advisor.

ME 701
Master's Thesis 6 credits
Prerequisite: department approval. Projects involving design, construction, experimental, or theoretical investigation carried out under the supervision of a designated member of the ME faculty. The completed written thesis must be defended in a publicly announced oral defense. A student must register for a minimum of 3 credits per semester. Degree credit will be limited to the 6 credits indicated for the thesis.

ME 710
Conduction Heat Transfer 3 credits
Prerequisite: ME 610. Heat transfer by conduction: differential and integral forms of the energy equation; analytical methods for transient and steady one-, two-, and three-dimensional heat transfer problems; and variational calculus applied to one-dimensional problems.

ME 711
Convection Heat Transfer 3 credits
Prerequisite: ME 610. Theory of convection heat transfer techniques in thermal design of complex systems; heat transfer in condensation and boiling; and analytical and digital computer methods for transient and steady-state heat transfer problems, including conduction, convection, radiation, phase change, and heat generation.

ME 712
Mechanics of Viscous Fluids 3 credits
Prerequisite: ME 611. Properties and behavior of real fluids in laminar and turbulent motion. Current mathematical and empirical laws and methods; flows in ducts; boundary layers over surfaces and bodies; fluid machinery; convective heat transfer applications including compressibility effects.

ME 717
Selected Topics in Mechanical Engineering I 3 credits
Prerequisite: department approval. Given when interest develops. Topics may include advanced mechanisms, aerodynamics, analysis of ME systems, design optimization, and case studies in design.

ME 718
Selected Topics in Mechanical Engineering II 3 credits
See course description for ME 717 above.

ME 719
Selected Topics in Mechanical Engineering III 3 credits
See course description for ME 717 above.

ME 721
Thermal Stresses 3 credits
Prerequisites: vector analysis or ME 616 or equivalent and theory of elasticity or ME 785. Thermoelasticity; reduction of thermoelastic problems to constant temperature equivalents; fundamentals of heat transfer; and elastic and inelastic stress analysis.

ME 725
Independent Study I 3 credits
Prerequisites: written permission from department chairman plus prerequisite courses prescribed by a supervising faculty member. Areas of study in which one or more students may be interested but which is not of sufficiently broad interest to warrant a regular course offering. A maximum of two independent studies courses may be applied to a degree.

ME 726
Independent Study II 3 credits
See course description for ME 725 above.

ME 727
Independent Study III 3 credits
See course description for ME 725 above.

ME 734
Analysis and Synthesis for Design 3 credits
Prerequisites: ME 616 or equivalent and ME 620 or ME 610. Fundamental concepts of advanced mathematics and their application to analysis and synthesis of mechanics, electricity, thermodynamics, fluid mechanics, and heat transfer systems and their components.

ME 735
Advanced Topics in Robotics 3 credits
Prerequisite: ME 625. Introduction to advanced topics and techniques in robotics. Subjects covered include differential kinematics, calibration and accuracy, trajectory control, and compliant motion control as well as an in-depth treatment of topics discussed in ME 625.

ME 736
Advanced Mechanism Design 3 credits
Prerequisite: ME 636. A study of advanced methods for the synthesis of mechanisms. Topics include synthesis of planar mechanisms for three, four and five positions, multiloop linages, change of branch and order problems, and optimal synthesis of mechanisms. Synthesis of linkages for special types of motion including straight line motion, cusp points on coupler curves and adjustable mechanisms.

ME 752
Design of Plates and Shells 3 credits
Prerequisites: ME 616 or equivalent and ME 620. A study of plates and shells. Mechanical engineering design solutions for typical loading and boundary conditions through analytical and numerical methods. Plate and shell interfaces and vibration are also considered.

ME 754
Pressure Vessel Design 3 credits
Prerequisites: ME 616 or equivalent and ME 620. Theories in designing pressure vessels; analysis of circular plates; cylindrical and spherical shells; pressure vessel heads; pipe bends; and attachments. Consideration is also given to pressure vessel materials in fatigue and creep designs.

ME 755
Adaptive Control Systems 3 credits
Prerequisite: ME 655. Theory and application of self-tuning and model reference adaptive control for continuous and discrete-time deterministic systems. Topics include model-based methods for estimation and control, stability of nonlinear systems and adaptive laws. Applications of adaptive control in mechanical systems and manufacturing processes.

ME 776
Dynamics of Polymeric Liquids 3 credits
Prerequisites: ME 610 and ME 611. An advanced course in fluid dynamics which concentrates on the behavior of polymeric liquids. Topics include constitutive equations of polymeric liquids, fluid dynamics of rheometry and kinetic theory of polymeric fluid dynamics.

ME 785
Theory of Deformable Solids in Mechanical Engineering I 3 credits
Prerequisites: ME 616 or equivalent and ME 620. Measure of strain; strain tensor; stress tensor; equilibrium equations; constitutive relations; compatibility conditions; conditions for and formulation of three-dimensional problems; and the relationship of engineering theories for beams, plates, and shells to the equations of elasticity.

ME 786
Theory of Deformable Solids in Mechanical Engineering II 3 credits
Prerequisite: ME 785. Solutions for problems formulated in ME 785: eigen-function solutions; operational methods; complex variables theory; three-dimensional problems; contact problems; wave propagation; and non-linear problems.

ME 790
Doctoral Dissertation and Research
Credits as designated
Required of all students working toward the Doctor of Philosophy in Mechanical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached and for 3 credits each semester thereafter.

ME 791
Graduate Seminar Non-credit
A seminar in which faculty or others present summaries of advanced topics suitable for research. Discussion of research procedures, thesis organization, and content. Students engaged in research will present their own research for discussion and criticism.

ME 792
Pre-Doctoral Research 3 credits
Prerequisite: permission of department chairperson. For students admitted to the Doctor of Philosophy program in mechanical engineering. Research is carried out under the supervision of designated ME faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under ME 790.

ME 793
Professional Project
Credits as designated
Required of all students working toward the Degree of Engineer. A minimum of 12 credits is required. Students must register for at least 6 credits of professional project per semester until completion of 12 credits. If the student is still actively engaged in the preparation of the project after completion of 12 credits, continued registration of 3 credits per semester will be required. Registration for 3 credits is permitted during the summer session.

ME 794
Mechanical Engineering Colloquium
Non-credit
Prerequisite: graduate standing and major in mechanical engineering. National and international experts in mechanical engineering will be invited to discuss their recent research. Required of all graduate students enrolled in ME graduate degree programs. Students must register in this course for at least two semesters and attend at least four lectures in each semester. Students with assistantships must register in this course every semester and attend regularly.

Mechanics

Offered by the Department of Civil and Environmental Engineering

Mech 540
Advanced Strength of Materials 3 credits
Prerequisite: mechanics of deformable bodies. Topics beyond the scope of elementary mechanics of deformable bodies are studied with particular emphasis on the assumptions, limitations, and applications to actual problems.

Mech 630
Theory of Elasticity 3 credits
Prerequisite: differential equations. Theory of elasticity as basis for both advanced stress analysis and for a critical examination of elementary stress analysis.

Operations Management and Systems

Offered by the School of Industrial Management

OM 701
Methods of Research in Operations Management and Systems 3 credits
Prerequisites: CIS 661, IE 616, IE 641, IE 651, MIS 648, or waived with approval of the Dean. Examines what is research? Why do research? What are the objectives of research? Covers need for research, criteria for good research and research design, concept of measurement, sampling design, primary data collection, experimentation and simulation, statistical and other types of analysis, and reporting of research findings.

Physics

Offered by the Federated Physics Department of NJIT and Rutgers-Newark

Phys 611/26:755:611
Advanced Classical Mechanics
3 credits
Prerequisite: undergraduate advanced mechanics or equivalent. Newton's laws of motion; mechanics of a system of particles; D'Alembert's principle and Lagrange's equations; derivation of Lagrange's equations from variational principle; conservation theorems and symmetry properties; the Hamilton equations of motion; canonical transformation, Poisson brackets; Hamilton-Jacobi theory; the rigid body equations of motion; small oscillations.

Phys 621/26:755:621
Classical Electrodynamics 3 credits
Prerequisite: undergraduate electromagnetism and working knowledge of ordinary and partial differential equations, special functions, complex variable functions, and ventor analysis. Electrostatics; magnetostatics; and boundary value problems; time-varying fields, Maxwell equations, conservation laws; plane and spherical electromagnetic waves; wave propogation in dielectric and conducting media; waveguides and resonant cavities.

Phys 631/26:755:631
Quantum Mechanics 3 credits
Prerequisite: Phys 611/26:755:611. Limits to classical physics; wave mechanics and the Schrodinger equation; uncertainty principle; eigenvalues and eigenfunctions of simple systems including quantum well, potential barrier, harmonic oscillator, and hydrogen atom; matrix mechanics, Hilbert space and operator method; approximation methods; scattering theory; time-dependent perturbation theory; quantization of electromagnetic radiation; quantum theory of angular momentum, spin.

Phys 641/26:755:641
Statistical Mechanics 3 credits
Prerequisite: Phys 631/26:755:631. Review of thermodynamic laws; ensemble theory; thermodynamic functions; classical ideal gas and imperfect gas; chemical reactions; Boltzmann, Bose-Einstein, and Fermi-Dirac statistics; quantum statistical theory of solids, magnetism and phase transitions.

Phys 651/26:755:651
Atomic and Molecular Physics 3 credits
Prerequisite: Phys 441 (see undergraduate catalog for description). Fundamentals of quantum mechanics; one-electron atoms; orbital angular momentum, spin, and total angular momentum; transition rates and selection rules; multi-electron atoms, LS coupling and JJ coupling; optical properties of atoms, the lasers; H_2 molecules; molecular bonding; molecular spectra; the Raman effect.

Phys 654/26:755:654
Nuclear and Particle Physics 3 credits
Prerequisite: Phys 441 (see undergraduate catalog for description). Nuclear stability; saturation of nuclear forces; two nucleon potentials for finite nuclei, the deutron; nucleon-nucleon scattering; effective interactions; nuclear matter; models of nuclear structure; nuclear excitations; description of elementary particle phenomenon; applications of scattering theory; conservation laws and symmetrical properties of interactions; structure of nucleons.

Phys 661/26:755:661
Solid-State Physics 3 credits
A brief review of basic concepts of quantum mechanics; free electron theories of metals; lattices in real and momentum space; electron levels in a periodic potential; the tight-binding method for calculating band structures; classification of solids; electrical and optical properties of semiconductors; cohesive energy; phonons; dielectric properties of insulators; magnetism; superconductivity.

Phys 667/26:755:667
Modern Experimental Techniques for Materials Processing and Characterization
3 credits
Prerequisite: Phys 441 or equivalent (see undergraduate catalog for description). *Part I Introduction*: bonding and material classification, phase transitions and phase diagrams, basic material structures and properties. *Part II Materials Processing*: various techniques for crystal growth and thin film fabrication. *Part III Materials Modification:* diffusion, ion implantation, and wet and dry etching. *Part IV Materials and Characterization*: chemical and structural, electrical, optical and mechanical techniques.

Phys 671/26:755:671
Applied Optics 3 credits
Maxwell's theory, linear and elliptical polarized light, Fresnel's equations, electromagnetic waves in crystals, dielectric functions, optical constants. Ellipsometry, interference, amplitude and wavefront dividing interferometry, Fabry-Perot interferometer, modes in layered structures. Fraunhofer and Fresnel diffraction, spatial coherence, Zernike's theorem. Symmetric and asymmetric Fourier transform spectroscopy. Fourier optics, imaging with quasi-monochromatic and monochromatic light, holography. Scattering of light. Geometrical optics of thin and thick lenses, aberration. Radiometry, blackbody, synchrotron, and laser radiation. Radiometric quantities.

Phys 675/26:755:675
Cellular Biophysics 3 credits
Prerequisites: differential and integral calculus and introductory physics. Lecture and lab covers the basis for cell membrane voltages, both static and dynamic. Basic biochemistry pertinent to biological systems, bioelectricity of the cell membrane, electrophysiology, and relevant microscopy. Laboratory sessions include electronics, bioelectric measurements both in artificial and biological cells, and microscopy.

Phys 687/26:755:687
Physics of Materials 3 credits
Prerequisite: Phys 441 or equivalent (see undergraduate catalog for description). Fundamentals of quantum mechanics; energy bands in crystals; electrical conduction in metals and alloys, semiconductors; optical properties of materials; quantum mechanical treatment of optical properties; magnetic properties of materials; thermal properties, heat capacity, and thermal expansion in solids.

Phys 689/26:755:689
Simulations of Electronic Device Structures 3 credits
Prerequisite: EE 657 or equivalent. Extensive introduction to the modeling programs used to stimulate devices and the processes used to build them. Standard software such as SIMION (for electron optics and vacuum microelectronic device physics), SUPREM (for process modeling), PISCES (for device

modeling), and ANSYSM and ANSYST (for finite element mechanical and thermal modeling) will be used. Each student will be assigned a final modeling project.

Phys 690/26:755:690
Directed Study of Applied Physics
3 credits
Directed study under the guidance of a physics faculty member on a topic of applied physics.

Phys 700/26:755:700
Master's Project 3 credits
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics who do not take Phys 701/26:755:701 Master's Thesis. An extensive paper involving experimental or theoretical investigation of a topic in microelectronics or other applied physics area is required. Cooperative projects with industry or government agencies may be acceptable. The project is carried out under the supervision of a designated physics graduate faculty member.

Phys 701/26:755:701
Master's Thesis 3 credits, 1st and 2nd sem.
Prerequisite: Written approval from graduate advisor. For students admitted to the Master of Science program in applied physics. Experimental or theoretical investigation of a topic in microelectronics or other applied physics area. Cooperative projects with industry or government agencies may be acceptable. The thesis is written under the supervision of a designated physics graduate faculty member. The completed written thesis should be of sufficient merit to warrant publication in a scientific or technical journal. The student must register for a minimum of 3 credits per semester. Degree credit is limited to 6 credits indicated for the thesis.

Phys 721/26:755:721
Classical Electrodynamics II
3 credits, 2nd sem.
Prerequisites: Phys 621 or equivalent, and basic knowledge of tensor analysis. Simple radiating systems, scattering and diffraction; special theory of relativity; dynamics of relativistic particles and electromagnetic fields; collisions between charged particles, energy loss, and scattering; radiation from an accelerated charge, synchrotron radiation, and bremsstrahlung.

Phys 731/26:755:731
Advanced Quantum Mechanics II
3 credits
Prerequisite: Phys 631/26:755:631 or equivalent. Review of quantum mechanics and theory of special relativity; second quantization; relativistic one-particle problem: Klein-Gordon equation and Dirac equation; canonical field theory; relativistic scattering theory; introduction to quantum electrodynamics and quantum field theory; Feynman diagrams, and applications.

Phys 732/26:755:732
General Relativity and Gravitation
3 credits
Prerequisites: Phys 611/26:755:611, Phys 621/26:755:621, and Phys 631/26:755:631, or equivalents. Review of special relativity; principles of equivalence and the metric tensor; tensor analysis; effects of gravitation; Einstein's field equations; the Schwarzschild singularity; gravitational radiation and cosmology.

Phys 761/26:755:761
Solid-State Theory 3 credits
Prerequisite: Phys 661/26:755:661 or equivalent. Fundamentals of group theory; symmetry of solids; application of group theory in solid-state physics; density functional theory; the one-electron approximation and energy bands; thermodynamic and transport properties; pseudopotentials and other methods of band structure calculation; Fermi liquid theory, collective excitation and mean field theory of superconductivity and magnetism; lattice vibrations, the electron-phonon interaction, and the BCS theory of superconductivity.

Phys 762/26:755:762
Electronic Structure of Solids 3 credits
Prerequisite: Phys 631/26:755:631 or equivalent. Tight binding theory; bond orbitals and the electronic structure of covalent solids; universal tight-binding parameters and the prediction of the bonding and dielectric properties of semiconductors; ionic solids and the bonding and dielectric properties of insulators. Theory of silicon dioxide and related compounds and their properties; transition metals and their compounds.

Phys 763/26:755:763
Surface and Interface Physics 3 credits
Prerequisite: Phys 661/26:755:661 or equivalent. Introduction to UHV (Ultra High Vacuum) technique; clean surface preparation; surface symmetry and LEED (Low Energy Electron Diffraction); surface and interface electronic structure and electron spectroscopy; XPS, UPS, AES and ESCA; surface compositional and geometric structure and EXAFS; STM (Scanning Tunneling Microscopy) and STS (Scanning Tunneling Spectroscopy).

Phys 771/26:755:771
Quantum Electronics 3 credits
Prerequisites: Phys 631/26:755:631 and Phys 651/26:755:651, or equivalents. Physics of lasers and the interaction of radiation with matter. Semiclassical and quantum theory of the interaction of the laser with single and multiple electromagnetic fields, and with homogeneously and Doppler-broadened media.

Phys 772/26:755:772
Applied Plasma Physics 3 credits
Prerequisites: Phys 621/26:755:621 and Phys 631/26:755:631, or equivalents. Properties of ionized systems, electromagnetic interactions, experimental techniques and selected topics on discharges and thermonuclear plasmas.

Phys 773/26:755:773
Particle-Solid Interactions 3 credits
Prerequisites: Phys 631/26:755:631 and Phys 661/26:755:661, or equivalent. The particle-solid interactions that form the basis for ion implantation, sputter deposition, reactive ion etching, and other microelectronic processing technology. Ion beam interactions with solids and solid state materials and structures. Rutherford backscattering experiments, and ion channeling. Methods for observing defect distributions in materials, surfaces, and surface layer interfaces using ion scattering techniques.

Phys 774/26:755:774
Principles of Spectroscopy 3 credits
Prerequisites: Phys 651/26:755:651 and Phys 761/26:755:761, or equivalents. Theoretical and experimental principles of spectroscopy. Atomic absorption, emission, IR (infrared), Raman, fluorescence, NMR, X-ray spectroscopies. Fourier transformation techniques. Coherent and incoherent sources.

Phys 775/26:755:775
Electrical Properties of Polymers 3 credits
Prerequisite: Phys 631 or equivalent. The course is intended for graduate students in applied physics, chemical engineering, materials science, and electrical engineering. Topics include introduction to polymers, electronic properties of polymers, theory of dielectric conduction, dielectric properties of polymers, dielectric values, and experimental techniques.

Phys 780/26:755:780
Current Topics of Applied Physics
3 credits
Current research interests in applied physics. Emphasis is on research work related to microelectronics, optoelectronics, optical physics, materials science, surface science, free electron laser and solar physics.

Phys 781/26:755:781
Physics of Advanced Semiconductor Devices 3 credits
Prerequisites: Phys 687/26:755:687 and EE 657, or equivalents. Physical principles and operational characteristics of the most important semiconductor devices for advanced electronics systems that process data at rates higher than 1 Gb/s, or handle analog signals at frequencies above 1 GHz. Devices addressed include: submicron MOSFET, MESFET, heterostructure MESFET, heterostructure bipolar transistors, quantum-effect devices, microwave devices, and photonic devices.

Phys 787/26:755:787
Physics of Sensors and Actuators
3 credits
Prerequisites: EE 657 and Phys 687/26:755:687, or equivalents. Fundamentals of sensors: optical, thermal, chemical, mechanical and electrical. Study of noise, phase-sensitive detection and other low-level measurement techniques. Semiconductor

surface microstructures, including temperature, pressure, strain, acceleration, humidity, mass flow, and gas sensors. Actuators, including micro-motors, micro-robots, and other micro-mechanisms. Semiconductor vacuum microelectronic devices.

Phys 789/26:755:789
Physics of Advanced Semiconductor Device Processing 3 credits
Prerequisites: EE 657 and Phys 687/26:755:687, or equivalents. Intended for doctoral students in applied physics, electrical engineering, and materials science. Silicon and GaAs technologies: crystal growth methods, epitaxy, oxidation, lithography, dry and wet etching techniques, polysilicon, diffusion, ion implantation, metallization (including silicidation), process integration, analytical characterization techniques, assembly and packaging, and yield and reliability.

Phys 790/26:755:790
Doctoral Dissertation and Research Credits as designated
Prerequisites: passing grade on departmental qualifying examination and approval of doctoral candidacy. Corequisite: Phys 791. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester until 36 credits are reached; 3 credits per semester are required thereafter. Registration for additional credits, up to 12 per semester, is permitted with the approval of the department graduate advisor. Experimental or theoretical investigation of a topic in applied physics, including microelectronics, materials science, and laser physics. Cooperative projects with industry or government agencies may be acceptable. Research and writing are carried out under the supervision of a designated graduate faculty member. The completed written dissertation should be a substantial contribution to the knowledge of the topic under research, and should be of sufficient merit to warrant publication in a leading scientific or technical journal.

Phys 791/26:755:791
Applied Physics Seminar Non-credit
Departments of physics at NJIT and Rutgers-Newark joint seminar on research and current topics in microelectronics, materials science, laser physics and other applied physics areas.

Phys 792/26:755:792
Pre-Doctoral Research 3 credits
Prerequisites: permission of the department. For students enrolled in the Ph.D. program to perform research in one of the designated applied physics areas under the supervision of an applied physics graduate faculty. If the student's research activity culminates in doctoral research in the same area, a maximum of 6 credits may be applied toward the 36 credits required under Phys 790.

Political Science

Offered by the Department of Political Science at Rutgers-Newark

26:790:504
Comparative Public Policy 3 credits
Approaches to the study of policy making in different political systems. Includes case studies.

26:790:510
Public Policy Analysis 3 credits
Focuses on approaches to the analysis of the policy-making process and the evaluation of its outputs. Emphasis on the policy agenda-setting processes, the politics of problem definition, policy decision-making strategies, cost-benefit analysis, the problem of legitimation and political feasibility, policy implementation, experimental evaluation research, and the role of values in policy analysis. Special attention given to the integration of empirical and normative research in the analytical process.

26:790:537,538
Recent International Relations 3 credits each
Contemporary issues in international relations. Problems treated vary from term to term.

26:790:571
American Politics and Public Policy 3 credits
Impact of American politics upon public policy issues of contemporary relevance.

Transportation

Offered by the Interdisciplinary Program in Transportation

Tran 552
Geometric Design of Transportation Facilities 3 credits
Prerequisite: CE 350 or equivalent. Design principles and criteria related to highways and railroads resulting from requirements of safety, vehicle performance, driver behavior, topography, traffic, design speed, and levels of service. Elements of the horizontal and vertical alignments and facility cross-section, and their coordination in the design. Computer-aided design procedures including COGO, CADAM, Digital Terrain Modeling. *Same as CE 552.*

Tran 553
Design and Construction of Asphalt Pavements 3 credits
Prerequisite: senior standing in civil engineering. Importance of designing asphalt pavements. Topics include the origin of crude, refining crude, types of asphalts, desired properties of asphalt cement, specification and tests for asphalt cement, aggregates for asphalt mixtures, aggregate analysis, gradation and blending, hot-mix asphalt (HMA) mix design, manufacture of HMA and HMA-paving, hot and cold recycling. *Same as CE 553.*

Tran 592
Co-op Work Experience 3 additive credits
Prerequisite: graduate standing and permission from Transportation Program and Office of Cooperative Education and Internships. Work assignments and projects are developed by the co-op office in consultation with the transportation program. Work assignments are related to student's major and are evaluated by Transportation Program faculty coordinators. Credits for this course may not be used to fulfill any transportation degree requirements.

Tran 602
Geographic Information Systems 3 credits
Geographical/Land Information System (GIS/LIS) is a computerized system capable of storing, manipulating and using spatial data describing location and significant properties of the earth's surface. GIS is an interdisciplinary technology used for studying and managing land uses, land resource assessment, environmental monitoring and hazard/toxic waste control, etc. Introduces emerging technology and its applications. *Same as CE 602.*

Tran 603
Introduction to Urban Transportation Planning 3 credits
Urban travel patterns and trends; community and land activity related to transportation study techniques including survey methods, network analysis, assignment and distribution techniques. Case studies of statewide and urban areas are examined. *Same as CE 603.*

Tran 604
Public and Private Financing of Urban Areas 3 credits
Ties government's budget, tax, policy, allocation of resources between public and private sectors, with the structure, development, and growth needs of urban metropolitan areas. Focuses on problems of poverty, transportation, land-use, economic base, relation between central cities and suburban areas, and alternative engineering and economic solutions. *Same as Fin 618 and MIP 618.*

Tran 608
Behavioral Issues in Transportation Studies 3 credits
Behavioral science concepts and principles such as perception, learning, motivation, and information processing as they relate to: transportation, consumer use of mass transit, automobiles, ridesharing and intelligent transportation systems. *Same as HRM 608.*

Tran 610
Transportation Economics 3 credits
Prerequisite: undergraduate course in economics. Principles of engineering economy. Cost of highway and public transportation facilities. Economic comparisons and evaluations. Financing approaches, tax allocation theory. Programming highway and public transit improvements. *Same as IE 610.*

Tran 615
Traffic Studies and Capacity 3 credits
Prerequisite: elementary probability and statistics. Presentation of the characteristics of the traffic stream, road users, and of vehicles, and a review of traffic flow relationships. Students are exposed to the principal methodologies followed by transportation practices to perform volume, speed, travel time, delay, accident, parking, pedestrian, transit and goods movement studies. Presentation of the principal methodologies used to perform transportation facility capacity analyses for: basic freeway sections, weaving areas, ramps and ramp junctions, multi-lane and two lane roadways, signalized and unsignalized intersections. Students get hands on experience using the highway capacity software (HCS) and SIDRA. *Same as CE 660.*

Tran 625
Public Transportation Operations and Technology 3 credits
Prerequisite: graduate standing in civil or industrial engineering or instructor approval. Presentation of the technological and engineering aspects of public transportation systems. Historical development of public transportation technologies. Vehicle and right-of-way characteristics, capacity and operating strategies. Public transportation system performance. Advanced public transportation systems. *Same as CE 625 and IE 625.*

Tran 640
Distribution Logistics 3 credits
Prerequisite: EM 602 or Tran 650 or equivalent. Distribution logistics emphasizing systems engineering techniques used to optimize corporate profit and customer service: transportation modes; inventory policies; warehousing and order processing; and the best logistics gross margin. *Same as EM 640.*

Tran 643
Transportation Finance 3 credits
Prerequisite: undergraduate course in economics. Balance sheets and income statements. Asset and liability management, sources and costs of debt and equity financing. Financial performance measures in the private sector (airlines, railroads, trucking and bus companies). Financing issues associated with the public sector (highways and mass transit). Equity and efficiency in pricing. Subsidy allocation formulae. Innovative financing schemes in the public sector. *Same as IE 643.*

Tran 650
Urban Systems Engineering 3 credits
Prerequisite: computer programming background. Identifies the various urban problems subject to engineering analysis, and modern techniques for their solution, including inductive and deductive mathematical methods, mathematical modeling and simulation, and decision making under uncertainty. *Same as CE 650.*

Tran 653
Traffic Safety 3 credits
Prerequisite: Tran 615 or equivalent. System behavioral principles are applied to safety aspects of highway operation and design, and improvements of existing facilities. Solutions are evaluated on the basis of cost effectiveness. *Same as CE 653.*

Tran 655
Land Use Planning 3 credits
Spatial relations of human behavior patterns to land use; methods of employment and population studies are evaluated; location and spatial requirements as related to land use plans; and concepts of urban renewal and recreational planning are investigated by case studies. *Same as CE 655.*

Tran 659
Flexible and Rigid Pavements 3 credits
Prerequisite: CE 341 or equivalent. Types of rigid (Portland cement) and flexible (bituminous pavements). Properties of materials, including mineral aggregates. Design methods as functions of traffic load and expected life. Importance and consequences of construction methods. Maintenance and rehabilitation of deteriorated pavements. *Same as CE 659.*

Tran 670
Transportation Demand Management 3 credits
Transportation demand management represents a set of policies implemented by both the government and private sector and used to change the consumption of transportation services. Investigates the effectiveness of measures such as parking management, rideshare adjustments, rideshare coordination and adjustable work hours, and the efficiency and distributional issues of such measures are explored. *Same as EPS 670.*

Tran 700
Master's Project 3 credits
Prerequisite: written approval of project advisor. An independent project demonstrating the student's professional competence in an area of specialization. Oral examination and written report required.

Tran 701
Master's Thesis 6 credits
Prerequisite: written approval of thesis advisor. A comprehensive project, usually in the form of substantial study and analysis, a functional design project or control-operations systems study.

Tran 702
Selected Topics in Transportation 3 credits
Prerequisite: Advisor's approval. Topics of special or current interest.

Tran 705
Mass Transportation Systems 3 credits
Prerequisites: Tran 610 and Tran 625. Investigation of bus, rapid transit, commuter railroad, and airplane transportation systems. Existing equipment, economics, capacity, and terminal characteristics are discussed, as well as new systems and concepts. Long- and short-range transportation systems are compared. *Same as CE 705.*

Tran 720
Discrete Choice Modeling for Travel Demand Forecasting 3 credits
Prerequisite: Tran 610 or equivalent. Discrete choice modeling describes a class of theoretical and analytical models essential for most advanced planning and forecasting efforts in transportation analysis. Includes logit, multinominal, and probit models. Develops theoretical and analytical skills needed to design, estimate and apply both revealed and stated preference models to appropriate travel demand forecasting problems. *Same as EPS 720.*

Tran 740
Management of Transportation Carriers 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Presents theory and practice of managing transportation carriers, including the concepts of costing, pricing, designing and marketing transportation service; the concepts of financial efficiency and resource productivity with application to the selected freight carriers in each mode of transportation. Selected case studies of carriers' operations management practices in various modes. Comparative studies of service characteristics, market share, cost structures both within a particular transportation mode and between modes. *Same as EM 740.*

Tran 751
Transportation Design 3 credits
Prerequisite: Tran 603. Design problems, airports, terminals, and highway intersections and interchanges are undertaken. *Same as CE 751.*

Tran 752
Traffic Control 3 credits
Traffic laws and ordinances; regulatory measures; traffic control devices; markings, signs and signals; timing of isolated signals; timing and coordination of arterial signal systems; operational controls; flow, speed, parking; principles of transportation system management/ administration; highway lighting; and state-of-the-art surveillance and detection devices and techniques. Hands-on experience with TRAF/NETSIM and FREESIM. *Same as CE 752.*

Tran 753
Airport Design and Planning 3 credits
Prerequisite or corequisite: Tran 610 or EM 693. Planning of individual airports and statewide airport systems. Functional design of air and landside facilities. Orientation, number and length of runways. Concepts of airport capacity. Passenger and freight terminal facility requirements. Airport access systems. FAA operating requirements. Financial, safety and security issues. *Same as CE 753 and IE 753.*

Tran 754
Port Design and Planning 3 credits
Prerequisite: Tran 610 or EM 693. Functional design of the water and landsides for general cargo, liquid and dry bulk, and container operations. Yard and storage systems. Port capacity in an intermodal network. Economic, regulatory, and environmental issues. *Same as CE 754 and IE 754.*

Tran 755
Intelligent Transportation Systems
3 credits
Prerequisite: Tran 752. Techniques used to improve the safety, efficiency and control of surface transportation systems. Emphasis on technological and operational issues of these systems and using them for incident detection and for traffic management through route and mode diversion.

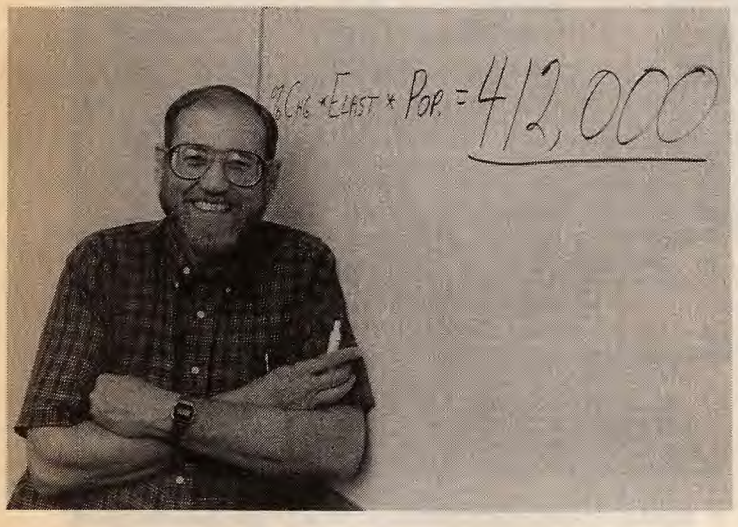
Tran 760
Urban Transportation Networks 3 credits
Prerequisites: elementary probability and statistics and Tran 650 or equivalent. Provides analytical techniques for the analysis of transportation problems in an urban environment. Principal components include applications of models for the analysis of transportation problems, advanced static, dynamic, and stochastic traffic assignment procedures and transportation network design exact and heuristic solution algorithms. Offers hands-on experience with existing software in traffic assignment and transportation network design.

Tran 765
Multi-Modal Freight Transportation Systems Analysis 3 credits
Prerequisites: Tran 610 or equivalent and Tran 650 or EM 602 or equivalent. Quantitative methods for the analysis and planning of freight transportation services. The supply-performance-demand paradigm for freight transportation systems. Cost and performance as determined by system design and operations. Relationship of traffic and revenue to service levels and pricing. Optimal service design and redesign for transportation enterprises and operations planning. Fleet and facility investment planning. Applications to various modes. *Same as EM 765 and CE 765.*

Tran 790
Doctoral Dissertation and Research
Credits as designated
Corequisite: Tran 791. Required of all candidates for the Doctor of Philosophy in Transportation. A minimum of 36 credits is required. Students may register for 6 to 15 credits of dissertation per semester. If more than 36 credits are necessary to complete doctoral dissertation and research, students must register for 3 credits per semester thereafter.

Tran 791
Doctoral Seminar Non-credit
Corequisite: Tran 790. A seminar in which faculty, students, and invited speakers will present summaries of advanced topics in transportation. Students and faculty will discuss research procedures, dissertation organization, and content. Students engaged in research will present their own problems and research progress for discussion and criticism.

Tran 792
Seminar Non-credit
Students periodically present the results of their research activities to faculty, research staff and other students. Outside speakers may be invited. Required each semester for those students who receive departmental or research-based awards.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STAMPER, EUGENE, Professor of Mechanical Engineering (1952). City College of New York, B.M.E., 1948; New York University, M.M.E., 1952.*

STEINBERG, ABRAHAM H., Professor of English (1955). Brooklyn College, B.A., 1937; Columbia University, Ph.D., 1955.

STEPHANS, CLARENCE H., Professor in Industrial Relations, Director of Relations with Industry, Director of Continuing Education Engineering Studies (1932). Newark College of Engineering, B.S., 1932.*

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WITTES, LEO, Assistant Professor of Applied Mechanics (1953). Rutgers University, B.S., 1928; University of Maryland, M.S., 1931.

ZAMBUTO, MAURO H., Distinguished Professor of Electrical Engineering (1962). University of Rome and Padua (Italy), Ph.D., 1944.

ZAMES, FRIEDA, Associate Professor of Mathematics (1972). Brooklyn College, B.S., 1954; New York University, M.S., 1966; Ph.D., 1972.

ZATZKIS, HENRY, Distinguished Professor of Mathematics (1953). Ohio State University, B.S., 1942; Indiana University, M.S., 1944; Syracuse University, Ph.D., 1950.

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BARTLE, ANDREW B., Architecture (1991). Bennington College, B.A.; Princeton University, M.Arch., 1980.†

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BELL, BRUCE A., Civil and Environmental Engineering (1995). New York University, B.S., 1968; M.S., 1969; Ph.D., 1974.*

BERNITZ, JOAN, Humanities and Social Sciences (1991). Queens College, B.A., 1951; Cornell University, M.A., 1952.

BOOKER, STUART M., Mathematics (1995). University of Warwick, B.Sc., 1988; University of Nottingham, Ph.D., 1991.

BOXER, RAYMOND, Humanities and Social Sciences (1990), Organizational and Social Sciences (1963). Upsala College, B.A., 1963; Fairleigh Dickinson University, M.A., 1967.

BRAUN, JACK, Electrical Engineering (1985). Rose Polytechnic Institute, B.S.E.E., 1966; Rose-Hulman Institute of Technology, N.S.B.E., 1970.

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BUECHEL, FREDERICK, Biomedical Engineering (1985). Seton Hall University, B.A., 1967; New Jersey Medical School, M.D., 1971.

BURNS, MICHAEL, Architecture (1992). Mercer County Community College, A.F.A., 1971; Drexel University, B.Arch., 1977.†

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CHEN, WAN-LING, Electrical Engineering (1993). National Tsing-Hua University, B.S.E.E., 1984; Michigan Technological University, M.S.E.E., 1986; Case Western Reserve University, M.S., 1988; New Jersey Institute of Technology, Ph.D., 1993.

CHOI, KWONG-KIT, Applied Physics (1990). University of Hong Kong, B.S., 1979; Yale University, Ph.D., 1983.

CIANCIA, ANDREW J., Civil and Environmental Engineering (1995). Rutgers University, B.S., 1968; M.S., 1970.*

COHEN, HARVEY, Electrical Engineering (1959). Newark College of Engineering, B.S.E.E, 1956; Yale University, M.S., 1958.

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DAVIE, GEORGE W., Industrial and Manufacturing Engineering (1994). Polytechnic Institute of Brooklyn, B.S., 1967; Fairleigh Dickinson University, M.B.A., 1976.

DEEK, MAURA ANN, Computer and Information Science (1986). Cook College, B.S., 1982; New Jersey Institute of Technology, M.S.C.S., 1986.

DELVECCHIO, GUY R., Industrial and Manufacturing Engineering (1985). New Jersey Institute of Technology, B.S.I.E., 1981; Rutgers University, M.S.I.E., 1984.

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DING, YUAN, Civil and Environmental Engineering (1995). Tsinghua University, B.S., 1984; M.S., 1987; Massachusetts Institute of Technology, M.S., 1992; New Jersey Institute of Technology, Ph.D., 1995.

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DUPRÉ III, ARTHUR M., Mathematics (1987). Woffard College, B.A., 1959; George Washington University, M.S., 1962; University of Maryland, College Park, Ph.D., 1965.

DURAN, WALTER, Biomedical Engineering (1985). Catholic University of Chile, Ph.D., 1965; Duke University, Ph.D., 1974.

ENGLISH, JERRY FITZGERALD, Esq., Environmental Science (1987). Stanford University, B.A., 1956; Boston University, L.L.B., 0000; Boston College Law School, J.D., 1963.

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FELDMAN, LEONARD, Applied Physics (1990). Drew University, B.A., 1962; Rutgers University, Ph.D., 1967.

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FISHER, ELLIOT A., Mathematics (1991). Cooper Union, B.S., 1973; California Institute of Technology, Ph.D., 1977.

FLEISCHER, DORIS, Humanities and Social Sciences (1988). Brooklyn College, B.A., 1958; New York University, M.A., 1961; Ph.D., 1979.

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FRIEDMAN, JEFFREY, Mechanical Engineering Technology (1992). New Jersey Institute of Technology, B.S.M.E., 1985; M.S.M.E., 1990.

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GOTLIEB, ITZHAK, Chemical Engineering (1989). Israel Institute of Technology, B.S., 1964; M.S., 1966; Michigan State University, Ph.D., 1970.

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OSOLINIEC, EDWARD, Electrical Engineering Technology (1984). New Jersey Institute of Technology, B.S.E.E., 1978; University of California, M.S.E.E., 1979.*

OWEIS, ISSA S., Civil and Environmental Engineering (1986). University of Baghdad, B.S., 1962; Oklahoma State University, M.S., 1965; University of Texas, Ph.D., 1968.*

PARDI, NINA, Humanities and Social Sciences (1989). Bucknell University, A.B., 1961; Kean College, M.A., 1986.

PARLAR, YUSUF, Electrical Engineering (1990). Middle East Technical University, B.S., 1981; Polytechnic Institute of New York, M.S., 1983; New Jersey Institute of Technology, Ph.D., 1990.

PASCHEDAG, ALLAN E., Mechanical Engineering (1977). New Jersey Institute of Technology, B.S., 1975; M.S., 1978.

PATNAIK, PRADYOT, Environmental Science (1995). Utbal University (India), B.S., 1970; M.S., 1972; Indian Institute of Technology (Bombay), Ph.D., 1976.

PATTERSON, SCOTT P., Civil and Environmental Engineering (1994). University of Cincinnati, B.S., 1971.*

PEPE, RUSSELL C., Electrical Engineering Technology (1991). New Jersey Institute of Technology, B.S.E.E., 1977; M.S.E.E., 1992.

PHILOBOS, ALEXANDER M., Industrial and Manufacturing Engineering (1990). Ain Shams University, B.S.M.E., 1967; Stevens Institute of Technology, M.S.M.E., 1975.

PIETRUCHA, BERNARD, Electrical Engineering (1986). New Jersey Institute of Technology, B.S.E.E., 1967; M.S.E.E., 1973; Rutgers University, Ph.D., 1985.

PISTACCHIO, JOHN, Electrical Engineering (1983). New Jersey Institute of Technology, B.S., 1981; M.S., 1985.

PRANTIS, NINA, Architecture (1986). Pratt Institute, B.F.A., 1976.

PRICE, ELIZABETH, Civil and Environmental Engineering (1986). Duke University, B.S., 1956; New Jersey Institute of Technology, M.S., 1975.

RHA, PETER, Electrical Engineering (1988). Rutgers University, B.S., 1979; University of Utah, M.S., 1982; Eng. Sc. D., 1984; Ph.D., 1985.

RISTIC, VOJISLA, Architecture (1992). University of Belgrade, B.Arch., 1982; New Jersey Institute of Technology, M.Arch., 1988; University of Pennsylvania, M.S.A.S., 1993.

RITTER, ARTHUR, Biomedical Engineering (1981). CUNY, B.S., Chemical Engineering, 1961; University of Rochester, M.S., 1968, Ph.D., Chemical Engineering, 1970.

ROCHE, TIMOTHY E., Mechanical Engineering (1993). New Jersey Institute of Technology, B.S., 1984; M.S., 1986.

ROMAN, HARRY, Industrial and Manufacturing Engineering (1985). New Jersey Institute of Technology, B.S.E.E., 1970; M.S.En.E., 1974.

RUSH, BENJAMIN, Biomedical Engineering (1985). University of California, Berkeley, B.A., 1944; Yale University, Medical School, M.D., 1948.

RUTH, SAMUEL A., Construction and Contracting Engineering Technology (1992). Newark College of Engineering, B.S.C.E., 1964.*

SANN, ROBERT I., Mechanical Engineering (1984). The City College of New York, B.M.E., 1952; New York University, M.S., 1956; Ph.D., 1964.*

SARKAR, SAMIR K., Mechanical Engineering (1980). Punjab University, B.S.M.E., 1960; Indian Institute of Science, M.Eng., 1963; New York University, M.Eng., M.E., 1966; M.Eng. Nuc.E., 1975.

SAU, RANJIT, Management (1995). Calcutta University, B.A., 1957; Jadavpur University, M.A., 1959; Wayne State University, Ph.D., 1964.

SCHAUBACH, JOHN W., Chemical Engineering (1995). Kansas State University, B.S., 1960; New Jersey Institute of Technology, B.S., 1985.

SEN ANUP KUMAR, Visiting Professor of Management (1992). Calcutta University, B.S., 1978; M.Tech., 1980; Ph.D., 1990.

SERICO, BENJAMIN J., Mechanical Engineering (1994). Newark College of Engineering, B.S., 1973; New Jersey Institute of Technology, M.S., 1975; Central Michigan University, M.A., 1978.

SHAKER, RIMA, Architecture (1989). Institut National des Sciences Appliquees de Lyon, B.C.E., 1982; Ecole Nationale des Ponts et Chaussees (ENCP), M.S., 1983; ENCP, Ph.D., 1986.

SIEGEL, JOY W., Architecture (1992). Syracuse University, B.Arch., 1982; Harvard University, M.Arch., 1985.†

SIMMONS, DIANE E., Humanities and Social Sciences (1994). University of Oregon, B.A., 1970; City College, City University of New York, M.A., 1991; City University of New York Graduate Schol, 1994.

SIMON, MICHAEL S., Industrial and Manufacturing Engineering. Rensselaer Polytechnic Institute, B.S., 1963; University of Maryland, J.D., 1965.

SIVAKUMAR, BALA, Civil and Environmental Engineering (1994). Indian Institute of Technology, B.Tech., 1980; Cornell University, M.S., 1982.*

SOLLOHUB, DARIUS, Architecture (1995). Columbia University, B.A., 1983; M. Arch., 1988.†

SOLU, JOHN C.R., Industrial and Manufacturing Engineering (1995). New Jersey Institute of Technology, B.S., 1975.

SPATOLA, JOSEPH, Environmental Science (1995). Syracuse University, B.S., 1960; University of Maryland, M.S., 1970; Ph.D., 1979.

SPENCER, THOMAS, III, Mathematics and Industrial and Manufacturing Engineering (1989). New Jersey Institute of Technology, B.S., 1964; M.S., 1967; Stevens Institute of Technology, M.S., 1969; Ph.D., 1976.

STAIGAR, JOSEPH, Civil and Environmental Engineering. New Jersey Institute of Technology, B.S., 1976; M.S., 1985.

STANDING, ALASTAIR, Architecture (1994). Kingston University (England), B.A., 1980.†

STEINBERG, HARVEY, Management (1982). City University of New York, B.A., 1954; Brooklyn Law School, J.D., 1958.

STORZ, RALPH H., Electrical Engineering Technology (1978). New Jersey Institute of Technology, B.S.E.T., 1977.

SUN, BEN, Electrical Engineering (1985). National Chiao-Tung University, B.S., 1977; Ohio State University, M.S., 1981; Ph.D., 1983.

SURJANHATA, HERLI, Mechanical Engineering (1988). Trisakti University, Eng. Degree, 1976; New Jersey Institute of Technology, M.S., 1984; Ph.D., 1993.

TANG, CHI, Industrial and Manufacturing Engineering (1993), China Textile University, B.S.E.E., 1982; New Jersey Institute of Technology, M.S.I.E., 1987.

THOMPSON, JOSEPH F., Humanities and Social Sciences (1979). Loyola University, B.A., 1971; Middlebury College, M.A., 1972.

TSATSOS, CONSTANTINE A., Mathematics (1989). New Jersey Institute of Technology, B.S., 1987; M.S., 1988.

TUTTLE, MARION, Industrial and Manufacturing Engineering (1972). Ladycliff College, B.A., 1964; St. John's University School of Law, J.D., 1967.

VALLELY, JOSEPH E., Electrical Engineering Technology (1993). City College of New York, B.E.E., 1962; M.E.E., 1965; Fairleigh Dickinson University, M.B.A., 1974.*

VAN DONGEN, DAVID B., Chemical Engineering (1995). SUNY-Buffalo, B.S., 1974; Clarkson College, M.S., 1976; University of Massachusetts, Ph.D., 1983.

VAN HOUTEN, NORMAN J., Industrial and Manufacturing Engineering (1992). County College of Morris, A.S., 1975; Jersey City State College, B.S., 1978; New Jersey Institute of Technology, M.S., 1991; Columbia Pacific University, Ph.D., 1994.

VIVIANI, ALBERT S., Industrial and Manufacturing Engineering (1976); Rutgers University, B.A., 1968; Stevens Institute of Technology, M.S., 1971; Newark College of Engineering, M.S.I.E., 1975.

VOGT, WILLIAM, Electrical and Computer Engineering Technology (1981). Newark College of Engineering, B.S., 1968; Stevens Institute of Technology, M.S., 1977.

WARREN, STEVEN J., Management (1983). City College of New York, B.B.A., 1950; M.B.A., 1952.

WEISS, JULIAN, Architecture (1982). Pennsylvania State University, B. Arch., 1963; Columbia University, M. Arch., M.U.D., 1980.†

WERDER, WALTER, Industrial and Manufacturing Engineering (1976). Rutgers University, B.S.C.E., 1949; Stevens Institute of Technology, M.S., 1953.

WHITE, ROBERT, Humanities and Social Services (1993). Rutgers University, B.A., 1967; M.A., 1972.

WILKES, KEVIN, Architecture (1986). Princeton University, A.B., 1983; Yale University, M.Arch., 1991.†

WILSON, LAUREL, Architecture (1990). University of Washington, B.F.A., 1982; Yale University, M.Arch., 1986.†

WUNNER, NICHOLAS J., Civil and Environmental Engineering. New Jersey Institute of Technology, B.S., 1976; M.S., 1979.

YATES, PENNY, Architecture (1989). New York University, B.A., 1968; Columbia University, M.F.A., 1971; Princeton, M.Arch., 1984.

YEH, H.T., Visiting Professor of Computer and Information Science (1989). National Taiwan University, B.S., 1960; University of Illinois, M.S., 1964, Ph.D., 1967.

ZEBEKOGLU, ILHAN, Architecture (1993). University of Stuttgart (Germany), Dipl. Ing. Arch., 1965; Harvard University, M. Arch., 1969.

ZIMMERMAN, ABRAHAM A., Chemistry (1995). City College of New York, B.S., 1951; Brooklyn College, M.S., 1957; New York University, Ph.D., 1962.

Rutgers-Newark Graduate Faculty

BASCH, NORMA, Professor of History; Ph.D., New York University.

BURKE, HUBERT H., Assistant Professor of Physics; Ph.D., Columbia University.

COWANS, JON, Assistant Professor of History; Ph.D., Stanford University.

DAIN, NORMAN, Professor of History; Ph.D., Columbia University.

FEIGHN, MARK E., Associate Professor of Mathematics; Ph.D., Columbia University.

GILMAN, JANE P., Professor of Mathematics; Ph.D., Columbia University.

GOLDEN, PETER B., Professor of History; Ph.D., Columbia University.

HOSFORD, DAVID H., Associate Professor of History; Ph.D., University of Wisconsin.

HUNCZAK, TARAS, Professor of History; Ph.D., University of Vienna.

KAFKEWITZ, DAVID, Professor of Biology; Ph.D., Cornell University.

KEYS, C. DAVID, Associate Professor of Mathematics; Ph.D., University of Chicago.

KIMBALL, WARREN F., Robert Treat Professor of History; Ph.D., Georgetown University.

LEVINSON, HENRY W., Associate Professor of Mathematics; Ph.D., New York University.

LEWIS, JAN E., Professor of History and Director, Graduate Programs, Federated History Department; Ph.D., University of Michigan.

LI, YUAN, Associate Professor of Physics; Ph.D., Indiana University-Bloomington.

LURIE, JONATHAN, Professor of History; Ph.D., University of Wisconsin.

MERKER, IRWIN L., Associate Professor of History; Ph.D., Princeton University.

MOSHER, LEE, Associate Professor of Mathematics; Ph.D., Princeton University.

MURNICK, DANIEL E., Professor Rank II of Physics; Ph.D., Massachusetts Institute of Technology.

OERTEL, ULRICH, Associate Professor of Mathematics; Ph.D., University of California-Los Angeles.

PRICE, CLEMENT ALEXANDER, Professor of History; Ph.D., Rutgers University.

RANDALL, JOHN D., Associate Professor of Mathematics; Ph.D., University of Warwick.

RUSSELL, FREDERICK, Associate Professor of History; Ph.D., Johns Hopkins University.

SAMATAR, SAID S., Professor of History; Ph.D., Northwestern University.

SATTER, BERYL E., Assistant Professor of History; Ph.D., Yale University.

SCZECH, ROBERT, Associate Professor of Mathematics; Dr.rer.Nat., University of Bonn.

SHAW, EARL D., Professor of Physics and Chairperson (Rutgers-Newark) of the Federated Physics Department; Ph.D., University of California-Berkeley.

STURM, JACOB, Associate Professor of Mathematics; Ph.D., Princeton University.

TAN, KI-SENG, Assistant Professor of Mathematics; Ph.D., Harvard University.

VERMES, GABOR, Associate Professor of History and Associate Chairperson, Federated History Department; Ph.D., Stanford University.

WAGENHEIM, OLGA J., Associate Professor of History; Ph.D., Rutgers University.

WEIS, JUDITH SCHULMAN, Professor of Biology; Ph.D., New York University.

WOU, ORDIC Y.K., Professor of History; Ph.D., Columbia University.

WU, ZHEN, Associate Professor of Physics; Ph.D., Columbia University.

Campus Directory

University Mailing Address: New Jersey Institute of Technology
University Heights
Newark, New Jersey 07102-1982
University Switchboard: (201) 596-3000
In New Jersey: 1 (800) 222-NJIT
NJIT on Internet: http://www.njit.edu
Many academic and administrative departments have home pages on the NJIT web site and are accessible at the address above.

Main Offices	Extension
Admissions: Graduate and Undergraduate	3300
Alumni Affairs	3441
Applied Science Program	3222
Biomedical Engineering Program	3584
Bursar	3148
Career Development Services, Division of	3100
Center for Environmental Engineering and Science (CEES)	3233
Center for Manufacturing Systems (CMS)	5856
Chemical Engineering, Chemistry and Environmental Science, Department of	3568
Civil and Environmental Engineering, Department of	2444
College of Science and Liberal Arts, Dean	3677
Computer and Information Science, Department of	3366
Continuing Professional Education, Division of	3060
Cooperative Education and Internships	3100
Electrical and Computer Engineering, Department of	3512
Employment	3140
Financial Aid	3479
Graduate Studies, Office of	3462
Hazardous Substance Management Research Center (HSMRC)	3233
History, Federated Department of NJIT	596-3377
and Rutgers-Newark	648-5410
Honors College, Albert Dorman	5780
Human Resources, Office of	3140
Humanities and Social Sciences, Department of	3266
Industrial and Manufacturing Engineering, Department of	3660
Intellectual Property, Office of	5825
International Students and Faculty, Office of	2451
Library, Robert W. Van Houten	3206
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Mechanical Engineering, Department of	3331
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Registrar	3236
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School of Industrial Management, Dean	3248
Sponsored Programs, Office of	3428
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Academic Calendar 1996-1999

During the academic year, most offices are open between the hours of 8:30 a.m. and 4:30 p.m., Monday through Friday. For the convenience of students, many offices, including the Registrar's Office, Finance Office, Dean of Students Office, Career Services Office, Hazell Center, and Counseling Center are open some evening hours. During the summer, most offices are open between 9 a.m. and 4 p.m., Monday through Friday, and some evening hours. Evening hours vary, so students should call before visiting.

FALL SEMESTER 1996

First day of classes	Tuesday, September 3
Last day to add a course	Monday, September 9
Fall Awards Ceremony	Wednesday, September 25
Last day for a refund	Monday, October 7
Deadline for applying for January commencement ceremony	Tuesday, October 15
Last day to withdraw from course(s)	Monday, November 4
Thanksgiving recess (no classes scheduled)	Thursday-Sunday, November 28-December 1
Last day of classes	Wednesday, December 11
Reading day	Thursday, December 12
Final exam period	Friday-Friday, December 13-20
Last day of Saturday classes	Saturday, December 14
Last day of Sunday classes	Sunday, December 15
Deadline for applying for May commencement ceremony	Monday, December 16
Fall grades due in Registrar's Office	Monday, December 23

SPRING SEMESTER 1997

First day of Sunday classes	Sunday, January 19
Martin Luther King Jr.'s Birthday (university closed)	Monday, January 20
First day of classes	Tuesday, January 21
Last day to add a course	Monday, January 27
Last day for a refund	Monday, February 24
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 17-23
Good Friday (no classes scheduled)	Friday, March 28
Saturday classes meet	Saturday, March 29
Easter (university closed)	Sunday, March 30
Last day to withdraw from course(s)	Monday, March 31
Classes follow a Friday schedule	Tuesday, May 6
Last day of classes	Tuesday, May 6
Reading day	Wednesday, May 7
Final exam period	Thursday-Thursday May 8-15
Spring grades due in Registrar's office	Friday, May 16
Commencement	Friday, May 23
First day of summer session	Tuesday, May 27
Deadline for applying for October graduation	Friday, August 15

FALL SEMESTER 1997

First day of classes	Tuesday, September 2
Last day to add a course	Monday, September 8
Fall Awards Ceremony	Wednesday, September 24
Last day for a refund	Monday, October 6
Deadline for applying for January commencement ceremony	Wednesday, October 15
Last day to withdraw from course(s)	Tuesday, November 4
Classes follow a Thursday schedule	Tuesday, November 25
Classes follow a Friday schedule	Wednesday, November 26
Thanksgiving recess (no classes scheduled)	Thursday-Sunday, November 27-30
Last day of classes	Wednesday, December 10
Reading day	Thursday, December 11
Final exam period	Friday-Saturday, December 12-19
Last day of Saturday classes	Saturday, December 13
Last day of Sunday classes	Sunday, December 14
Deadline for applying for May commencement ceremony	Monday, December 15
Fall grades due in Registrar's Office	Monday, December 22

SPRING SEMESTER 1998

First day of Sunday classes	Sunday, January 18
Martin Luther King Jr.'s Birthday (university closed)	Monday, January 19
First day of classes	Tuesday, January 20
Last day to add a course	Monday, January 26
Last day for a partial refund	Tuesday, February 24
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 16-20
Last day to withdraw from course(s)	Monday, March 30
Good Friday (no classes scheduled)	Friday, April 10
Saturday classes meet	Saturday, April 11
Easter (university closed)	Sunday, April 12
Classes follow a Friday schedule	Tuesday, May 5
Last day of classes	Tuesday, May 5
Reading day	Wednesday, May 6
Final exam period	Thursday-Thursday May 7-14
Spring grades due in Registrar's office	Friday, May 15
Commencement	Friday, May 22
First day of summer session	Tuesday, May 26
Deadline for applying for October graduation	Friday, August 14

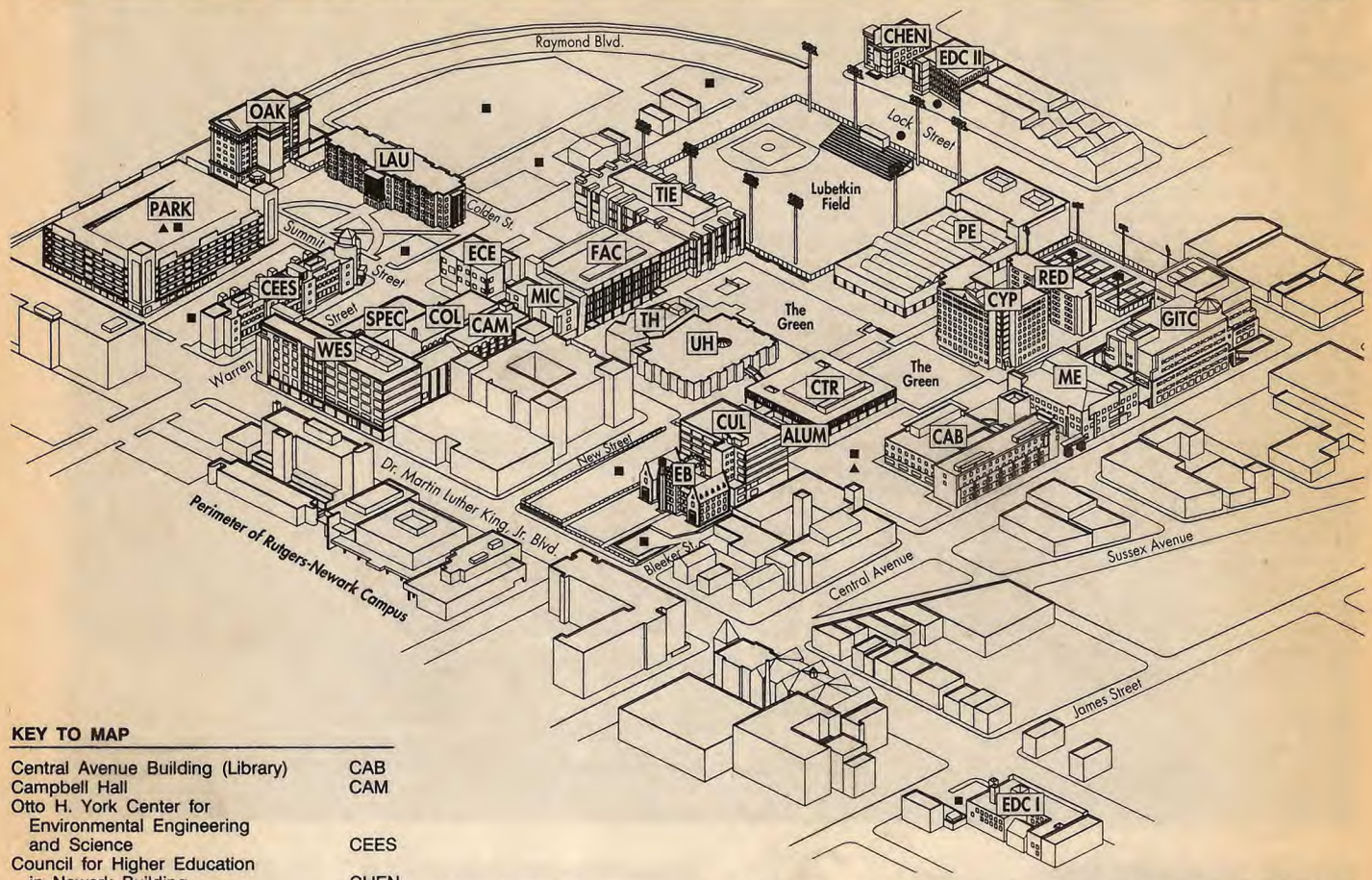
FALL SEMESTER 1998

First day of classes	Tuesday, September 1
Saturday classes meet	Saturday, September 5
Sunday classes meet	Sunday, September 6
Labor Day (university closed, no classes scheduled)	Monday, September 7
Classes follow a Monday schedule	Tuesday, September 8
Last day to add a course	Tuesday, September 8
Fall Awards Ceremony	Wednesday, September 23
Last day for a refund	Tuesday, October 6
Deadline for applying for January commencement ceremony	Thursday, October 15
Last day to withdraw from course(s)	Tuesday, November 3
Classes follow a Thursday schedule	Tuesday, November 24
Classes follow a Friday schedule	Wednesday, November 25
Thanksgiving recess (no classes scheduled)	Thursday-Sunday, November 26-29
Last day of classes	Thursday, December 10
Classes follow a Tuesday schedule	Thursday, December 10
Reading day	Thursday, December 11
Last day of Saturday classes	Saturday, December 12
Last day of Sunday classes	Sunday, December 13
Final exam period	Monday-Monday, December 14-21
Deadline for applying for May commencement ceremony	Tuesday, December 15
Fall grades due in Registrar's Office	Wednesday, December 23

SPRING SEMESTER 1999

First day of Sunday classes	Sunday, January 17
Martin Luther King Jr.'s Birthday (university closed)	Monday, January 18
First day of classes	Tuesday, January 19
Last day to add a course	Monday, January 25
Last day for a refund	Tuesday, February 23
Spring Recess (university open, no classes scheduled)	Monday-Sunday, March 15-21
Last day to withdraw from course(s)	Tuesday, March 30
Good Friday (no classes scheduled)	Friday, April 2
Saturday classes meet	Saturday, April 3
Easter (university closed)	Sunday, April 4
Classes follow a Friday schedule	Tuesday, May 4
Last day of classes	Tuesday, May 4
Reading day	Wednesday, May 5
Final exam period	Thursday-Thursday May 6-13
Spring grades due in Registrar's office	Friday, May 14
Commencement	Friday, May 21
First day of summer session	Monday, May 24
Deadline for applying for October graduation	Monday, August 16

Map of the NJIT Campus



KEY TO MAP

Central Avenue Building (Library)	CAB
Campbell Hall	CAM
Otto H. York Center for Environmental Engineering and Science	CEES
Council for Higher Education in Newark Building	CHEN
Colton Hall	COL
Hazell Center	CTR
Cullimore Hall	CUL
Cypress Hall	CYP
Eberhardt Hall	EB
Electrical and Computer Engineering Extension	ECE
Enterprise Development Center I	EDC I
Enterprise Development Center II	EDC II
Faculty Memorial Hall	FAC
William S. Guttenberg Information Technologies Building	GITC
Laurel Hall	LAU
Mechanical Engineering Center	ME
Microelectronics Center	MIC
Oak Hall	OAK
Physical Education Building	PE
Redwood Hall	RED
Specht Building	SPEC
Tiernan Hall	TIE
Theater	TH
University Hall	UH
Weston Hall	WES
Wilson Alumni Center	ALUM
Parking	■
Parking Deck	□
Guest Parking	▲
Newark Subway (Warren St. Station)	●

Travel Directions

BY CAR

Garden State Parkway (GSP): Take exit 145 to Route 280 East, then follow Route 280 East directions.

New Jersey Turnpike: Take exit 15W to Route 280 West, then follow Route 280 West directions.

Route 280 West: Take Exit 15 (Route 21, Newark), immediately after the William Stickel Memorial Bridge. At light at foot of ramp, make soft left on University Avenue. At fourth light, make a right on Central Avenue. Make a left on King Blvd. At first light, turn right on Warren Street. Make second left on Colden Street and follow signs to the NJIT parking deck.

Route 280 East: Take Exit 14A, King Blvd. Make a right at the light at the foot of the ramp. Bear right through first light, staying on King Blvd. Go three more lights and make a right on Warren Street. Make a second left on Colden Street and follow signs to the NJIT parking deck.

Route 1 & 9 North & South: Take exist marked Newark, Route 21 (McCarter Highway). Cross bridge. At light at end of bridge, make quick left then quick right for Broad Street. (There are clear signs for Broad St.) Go about 1 mile. Make a left on Court Street. Make right at third light on King Blvd. Make left at fifth light on Warren Street. Make second left on Colden Street and follow signs to the NJIT parking deck.

Route 78: Take Route 78 to the Garden State Parkway. Follow GSP directions.

Route 22: Take Route 22 to Route 21 North. Follow directions for Route 21 North.

Route 21 North: Cross bridge. At light at end of bridge, make quick left then quick right for Broad Street. (There are clear signs for Broad Street.) Go about 1 mile. Make a left on Court Street. Make right at third light on King Blvd. Make left at fifth light on Central Avenue. Make second left on Colden Street and follow signs to the NJIT parking deck.

Route 21 South: Make a right on Market Street. Bear right at fork. Make right at top of hill on King Blvd. At first light, make a left on Warren Street.

New York Thruway: Thruway to Exit 14A, Garden State Parkway. Follow Parkway directions above.

George Washington Bridge: NJ Turnpike South to Exit 15W. Follow Route 280 West directions.

Lincoln Tunnel: West on Route 3 to NJ Turnpike South to Exit 15W. Follow Route 280 West directions.

Visitor Parking at NJIT is available in the NJIT parking deck, located near the corner of Warren and Summit streets with access from Colden Street. Visitor parking may be reserved in advance through your host. Other parking is available on campus during weekend activities and special events.

OTHER TRANSPORTATION SYSTEMS

Newark International Airport: Five miles from NJIT campus. A minibus (Newark Airlink) or taxi service connects the airport with Penn Station in Newark. Bus, city subway and taxi connections may be obtained at the station.

Newark Penn Station: Connections to the NJIT campus may be made by bus, city subway, or taxi.

Morris & Essex Broad Street Station: A five-block walk to the NJIT campus via King Blvd. to Central Avenue. Taxi service is also available.

Newark City Subway: From Penn Station in Newark, take the Warren Street stop for the NJIT Campus.

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Michael Paras 17, 163, 165; Mike Peters 3, 16, 17, 24; Brian Buckley 141;
Dave Hollander 21; Steve Jordan 17

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New Jersey Institute of Technology
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